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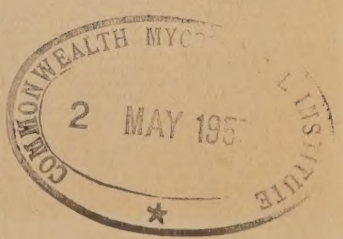

BIOLOGICAL AND PRACTICAL RESEARCHES INTO BLUEING IN PINE AND SPRUCE

BIOLOGISKA OCH PRAKTISKA UNDERSÖKNINGAR ÖVER BLÅYTA HOS TALL OCH GRAN

BY

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Pinus silvestris.

Picea excelsa.

Ceratostomella cœrulea.

Ceratostomella Piceæ.

Ceratostomella pluriannulata.

Ceratostomella Pini.

Pinus silvestris.

Picea excelsa.

Endoconidiophora cœrulescens.

Discula pinicola.

Discula pinicola var. mammosa.

Hormodendrum cladosporioides.

Pinus silvestris.

Picea excelsa.

Cadophora fastigiata.

Leptographium Lundbergii.

Trichosporium tingens.

Hormonema dematioides.

Pinus silvestris.

Picea excelsa.

Alternaria humicola.

Sclerophoma entoxylina.

Xylomyces I.

Penicillium biforme.

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BIOLOGICAL AND PRACTICAL RESEARCHES INTO BLUEING IN PINE AND SPRUCE.

The researches and investigations published in this book were commenced in the year 1923. According to the plan that had been drawn up a purely scientific research into the nature of blueing and its ecological conditions was to be carried out on the one hand, and on the other practical tests were to be made for the purpose of ascertaining the most suitable methods of storing timber so as to prevent the occurrence of blueing.

It was originally our intention to restrict our studies of the blueing fungi in so far that pure cultures were only to be made in conjunction with the practical tests. As, however, the isolation results from the very start took a very interesting and unexpected turn — they seemed namely to prove that *Hyphomycetes* and *Sphæropsidaceæ* play a greater part as blueing fungi than *Ascomycetes* — it became necessary to make a more comprehensive investigation into the nature of the blueing fungi. Isolation tests were therefore made with timber from various parts of Sweden. In the course of these tests not only trees on the roots but also lumber and sawn timber stored in timber yards were investigated.

The isolation of the fungi and their pure culture as well as the experimental investigations into their biology have been carried out by MELIN. The morphological and systematic treatment of the fungi has been carried out mainly by LAGERBERG. The results of these researches are presented in Part I.

The culture tests have been made at the Mycological Laboratory attached to the College of Forestry.

The practical tests were carried out in the Garpenberg State Forest in Dalecarlia (Central Sweden) where the Board of Demesnes very liberally placed all the test material at our disposal, and these tests

were carried on from 1923 to 1924. The results of these tests will be treated by LUNDBERG in Part II.

Although the practical tests at the outside aimed at the study of the influence of different methods of storing upon the occurrence of blueing, other forms of damage, chiefly decay and cracking, have also been studied. Moreover, in this connection the course of evaporation, especially in summer-felled timber, has been the subject of thorough and close study. We have deemed it advisable to present results of these researches in Part II.

In the carrying out of the practical tests we have had extremely valuable assistance from MARTIN ENANDER, Chief Assistant Forester at Garpenberg, and we therefore wish to convey to him our thanks for the same.

Mr ENANDER has also during the years 1924—25 on his own initiative been carrying out some complementary researches into the effect of different forms of storage upon the development of blueing and other damage caused in round timber. The results obtained by him in this connection have been very kindly placed at our disposal and are partly referred to in Part II.

Of the figures included in Part I — all of them originals — the drawings, which have been made by LAGERBERG, have been produced by the aid of Abbe's drawing apparatus and reduced in reproduction.

Our investigations have been made possible through a grant received from the »Fund for Forest-Scientific Research» for which we beg to express our gratitude.

College of Forestry, Stockholm, in the month of March, 1927.

The Authors.

PART I.

BLUEING FUNGI AND THEIR BIOLOGY.

1. Previous statements as to the origin of blueing.

The first to connect blueing with fungi appears to be R. HARTIG (1878, p. 66). In his investigations of wound-rot in trees he had occasion to refer to a form of fungus, »*Xenodochus ligniperda*», described by WILKOMM (1866) who considered it to be the cause of the so-called »Rotfäule» in pine and spruce. HARTIG suggests that in reality it belongs to »*Ceratostoma pilifera (Sphæria dryina)*» which he assumes is the cause of the blueing of coniferous timber. *Ceratostoma piliferum* has as a consequence long been looked upon as the specific blueing fungus, and it was really not until 1906 that this idea began to lose ground.

In 1878 SACCARDO (p. 370) established the genus *Ceratostomella* for those kinds of *Ceratostoma* which had colourless spores; the old form known as *piliferum* was included in this new genus by WINTHER (1887).

The result of the first more thorough examinations of the ravages caused by blueing was published a few years later in North America by VON SCHRENK (1903). These had been observed in the wood of *Pinus ponderosa*, and the responsible fungus, which is described as *Ceratostomella pilifera*, is also treated in detail. The description of blued timber which is given in LAFAR's hand-book on technical mycology and is compiled by VON TUBEUF (1904—06) refers principally to the discoveries of VON SCHRENK.

It soon became very evident, however, that the etiology of blueing required far more thorough investigation. To start with we must remember that *Ceratostoma piliferum*, which was described by ELIAS FRIES in 1822, was not treated as a uniform species in the systematic works of later mycologists. In 1869—70 already FUCKEL thus describes no less than four different forms: *vulgaris*, found in hard and dry oak-wood, *tenuissima* from pine-wood affected by decay but still firm, *pinastri* Nees from old pine-bark and *capillata*, which was found in a decaying fruit body of a *Polyporus*. He admits, however, that he was unable to form any decided opinion as to the systematic value of these forms; the scanty diagnoses do not, as a matter of fact, allow of identification and can therefore scarcely be of more than historical interest to us now. We find them, however, in an unchanged condition in the account of *Ceratostomella pilifera* which WINTHER contributed to RABENHORST's Crypto-

gam Flora (1887); WINTHER, however, suggests that among them just as many species might probably be concealed.

It was not until 1907 that the real importance of *Ceratostomella pilifera* became apparent, when MÜNCH first disclosed the results of his interesting researches in Germany as regards the nature of blueing. His work is still the most important contribution to the solution of this practical and significant question. By careful pure culture MÜNCH was able to prove that *Ceratostomella pilifera* was a denomination for quite a heterogeneous mixture; not only had various species, quite distinct both morphologicaly and biologicaly, been classified under this name but the same had probably also referred to a type for the new genus which he considered it necessary to establish.

MÜNCH isolated and examined in detail four species of the *Ceratostomella*, viz. *C. Pini*, *C. Piceæ*, *C. cana* and *C. cœrulea*, of which the first mentioned was well characterized by the smallness of the perithecia, and the rest, which had larger and long-necked fruit bodies, which did not appear to show any systematically practicable distinctive characteristics, he combined under the name of the *pilifera*-group, the only form under which the original name has been preserved in his work. The species in the *pilifera*-group, however, could be distinguished principally by their accompanying conidial stages. It may be pointed out that MÜNCH has probably under-estimated the possibilities of obtaining practicable distinguishing characteristics from the perithecia, and on the other hand we must admit that the conidial stages, especially those of the *Cladosporium* and *Cephalosporium*-type, do not always provide a systematically reliable guidance.

On a fifth species with the perithecia of the *Ceratostomella*-type MÜNCH established the new genus of *Endoconidiophora*, the form being called *E. cœrulescens*. The reason for this division was the extraordinary conidial stage which proved to be identical with that previously described as *Chalara Ungeri* belonging to the *Dematiaceæ*.

Of other kinds of fungi which grow on the blued timber MÜNCH only studied a *Cladosporium*-form. This was found in profusion in the blackened mycelium cover which develops on the sapwood of the timber of the spruce and silver fir only a few days after felling. Attempts to produce blueing on newly hewn timber by inoculating it with pure cultivated fungus failed, however. MÜNCH finally comes to the conclusion that the genus *Ceratostomella* and the genus *Endoconidiophora*, which is so nearly related to it, contains the blueing fungi par préférence.

At the same time as MÜNCH was carrying out his researches into blueing fungi in Germany, the question was also an object of interest

to mycologists in North America. Here HEDGCOCK had already in 1906 announced the results of his rather extensive investigations into the blueing fungi of the New World. His work is, however, predominatingly systematic. His methods were the same, i. e. he endeavoured to find out which were the most active species by isolating in pure culture various fungus-forms of blued timber and transfering them to healthy wood. As may be expected the *Ceratostomella* genus is well represented in his accounts. HEDGCOCK retains here the name *pilifera* for a species which has been proved to be widely disseminated in the United States in timber from several species of *Pinus*, and which he considers to be the most important of the blueing fungi. Furthermore there is also treated *Ceratostomella echinella* set up by ELLIS and EVERHART and described as no less than six new species, namely *C. Schrenkiana, C. capillifera, C. pluriannulata, C. minor, C. exigua* and *C. moniliformis.* It would, of course, be interesting to ascertain to what extent these species are identical with the European ones. MÜNCH, however, has not attempted any comparison. SACCARDO (1913, p. 293), after having accentuated the desirability of attempting this task, has left it to others to perform. It could not be carried out, however, with any great advantage and in any case access to the original material would be necessary for it to be of any value. If one studies more closely the diagnoses made by HEDGCOCK it appears that in several cases doubt must in our opinion exist as to the validity of the species, especially when scarcely perceptible differences in the size of the perithecia or conidia have been given an important place in the characterisation of species. Our long experience in the cultivation of the Swedish *Ceratostomella*-forms has shown that they may vary very considerably.

The biology of some of the North American blueing fungi has subsequently been the object of investigation by Miss RUMBOLD (1911), who, however, has not made any more detailed tests as to their identity with European forms. One gathers from her statements that the *Endoconidiophora*-type is also more widely spread in America, a fact which is of interest, for, as far as is known, this type was not included in HEDGCOCK's material. It is uncertain, however, whether that which is described by Miss RUMBOLD really refers to *E. cærulescens.* The isolation of the fungus from another substratum — planks of *Liquidambar styraciflua* — does not mean very much in this case, but the measurements of the perithecia given are more important and seem to show that another, although closely related species, has been discovered. The rather considerable neck-length of 5 300 μ makes it necessary to accept such an assumption. It is not clear, however, if this figure refers to a maximum

or average value, at any rate it so considerably exceeds the same measurement in the *Endoconidiophora cærulescens* that a series of intermediate neck-lengths could scarcely occur. In the last-named species the average length of the necks of the perithecia only amounts to about $^1/_7$ of the above-mentioned figure and the longest neck observed by us only $^1/_5$ of that (cf. further p. 200). Greater uniformity is undoubtedly shown by the neck-cilia, spores and conidia.

Even if at present we cannot estimate how many of the blueing *Ceratostomella* species are common to the New and the Old Worlds, we may at least take for granted that some of them are. Two such forms as *C. Pini* and *C. cærulea* are no doubt to be found in the entire zone of the Northern coniferous forests. None of the smaller forms described by HEDGCOCK seems to be identical with *C. Pini*. It is apparent, however, from a treatise by HUBERT, published a few years ago (1921, p. 220), that this fungus is also to be found in North America. He had isolated a mycelium from blued timber of *Pinus Strobus* which, as far as the nature of the conidial formation and appearance of the conidia are concerned, showed distinct conformity with that described and illustrated by MÜNCH for *C. Pini*. It also appears to us not improbable that the species of *capillifera, pilifera* and *Schrenkiana* established by HEDGCOCK might on a fresh examination prove to be connected with *Ceratostomella cærulea*. Naturally one cannot take for granted that all the species of this genus which are to be found in Europe have already been discovered. Several of the North American species which are unknown to us, may be well-established and may in time also be detected here. A case in point is that HEDGCOCK's species *pluriannulata* has already been proved to belong to the Swedish fungus flora, and the probability is that it is also to be found in other European countries.

If HEDGCOCK, as mentioned, in the first instance makes his *Ceratostomella pilifera* and also, although in a smaller degree, other species of that genus responsible for the blueing of timber, it is because he does not include in this damage such discoloration as shades of brown and black. He has brought together into a separate group the fungi which cause these colours, and which in his material consist entirely of *Hyphomycetes*: 7 species of the genus *Graphium*, of which 2 are described as new, 2 of species *Hormodendrum*, of which 1 is new, and one mycelium, which is assigned to the genus *Hormiscium* and is described as *H. gelatinosum*. A few more species are also enumerated which give the sapwood a more superficial discoloration, and were therefore considered to be of subordinate practical importance: *Alternaria*

tenuis Nees, *Stachybotrys alternans* Bon., *Chætomium* sp., *Gliocladium* sp., and strange to say also a *Stemonites* form, which would scarcely be of any interest in this connection.

Finally we may add that in America still another species of fungus has proved to be connected with the blueing of timber, viz. *Lasiosphæria pezizula* (B. et C.) Sacc. According to HUBERT (1921, p. 214), this form, however, seems in the first place to be found on hard-woods (*Fagus atropunicea*, *Liquidambar styraciflua* and *Diospyros virginiana*), to the sapwood and sometimes even to the heartwood, which it imparts an olive grey shade.

The above survey perhaps convey the impression that the blueing fungi have, at any rate on the whole, been well investigated. This is, however, not the case. The rather one-sided interest which has been devoted to the *Ceratostomella* genus has no doubt afforded a fair insight into the importance of these species, but at the same time such investigations have resulted in other groups being ignored or, in any case, only treated in a very fragmentary manner. Our investigations have proved that among the *Sphæropsideæ*, and above all among the *Hyphomycetes*, forms are found of the blueing fungi which are just as active as the *Ceratostomella*-group, and in many cases even more so. Several of them are also evidently very widely distributed.

Saprophytic fungi with dark-coloured mycelia are to be found in abundance, and their ability to utilize substrata of the most varying nature is well-known. This being the case it is not surprising to find that many forms can be made responsible for the discoloration of timber. In order to ascertain to what extent this takes place we have only one method to resort to, viz.: to isolate and to make pure cultures of mycelia which grow on blued timber and to ascertain their activity by inoculating each separately on sterilized wood. By adopting this method we have succeeded in establishing several hitherto unknown but important blueing fungi, and we have at the same time come to the conclusion that it would be very advantageous to continue investigations on these lines, as undoubtedly numerous and practically important forms still remain to be discovered.

We have used as substratum malt-agar (5 % malt extract, 1,5 % agar) for isolation purposes and also for subsequent cultures. During the isolation process a raw culture has first been prepared by transferring very small pieces of discoloured wood to agar plates. From these raw cultures pure cultures have afterwards been obtained through the ordinary dilution-method used in bacteriology in which the spores or conidia of the raw cultures

have formed the basis. From the pure cultures already mentioned the spores or conidia have again been transferred to the tangential surface of partially sterilized sectors of slabs of pine and spruce (cf. Plates I and II).

2. Forms and origin of discoloration.

It is well-known that it has long been the custom to indicate as »blued» all timber which is darkened by fungi, although not damaged by decay. This term must, however, not be taken too literally, for in reality these stains appear almost more often without a trace of blue in them. A detailed characterization often encounters great difficulties. The shades are, in fact, so specific that they can scarcely be found in the current colour-scales. We may add here another important factor, namely that these shades undergo a considerable change according to the water-content of the timber; the quality of the colour and also its degree of saturation are largely dependent on this factor, as has previously been pointed out by VON SCHRENK (work cited, p. 25). Slate-grey, grey-brown, greenish grey-brown, brown-black, blue-black and other shades may be met with. The printing of the word »Blauwerden» in inverted commas by HARTIG in his above-mentioned work is undoubtedly accounted for by the multiplicity of shades.

Attention should be drawn to the fact that the nature of the blueing-stain is also directly influenced by the colour of the fungus. This has been proved by our numerous pure culture experiments on timber. One may also very easily convince oneself by means of the microscope that the dark, coarse hyphæ which are growing within the wood have totally different tints in different species. In some the walls are pure tobacco-coloured brown, whilst in others greyish-green is more noticeable. MÜNCH (1908, p. 305), in his pure culture of species of *Ceratostomella* and *Endoconidiophora*, made the interesting observation that the colour of the mycelium in the same fungus was not constant but changed according to the substratum on which it was cultivated. This did not only a apply to the intensity of the colour but also to the shade. For instance the mycelia of *Ceratostomella Pini* and *C. cærulea*, which are in nature the most effective of wood bluers, became entirely colourless when grown on cane-sugar and peptone, whilst *C. Piceæ*, which, according to several observations and also from our own, may only exceptionally have any importance as a blueing fungus, developed to the naked eye a black mycelium covering when the

carbon sources consisted of cane sugar.[1] MÜNCH considers it not impossible that the last-mentioned species' extremely varying ability to discolour timber, at any rate partly, may be connected with the varying contents of the cells of the wood. As a result of his discoveries on the connection of the colour of the mycelium with the source of nourishment he states that the colour must only be used with circumspection as a characteristic of the species. No objections can, of course, be raised to such a statement. Wood, however, as a source of nourishment is hardly subjected to any great changes, but on the contrary provides the fungi with fairly stable conditions for development. One should therefore be able to use diagnostically the colours which are produced in nature in this substratum, unless the problem is further complicated by several different mycelia growing together in the same piece of timber, as is often the case. Examples of this will be found in the descriptions of localities of discovery and substrata under the species which are more particularly treated in this work. It is obvious that this mixing of the mycelia also tends to render more difficult the investigation into the question of species of the blueing fungi; without due caution one may easily refer different forms of fungi to one species, although they have, as a matter of fact, nothing whatever to do with each other.

Even if the so-called blueing often lacks every trace of blue, there are cases where a fairly conspicuous bluish tint is quite apparent. How this can occur under the stated conditions, has long been an object of speculation, and explanations, more or less feasible, have already appeared in litterature. Thus VON SCHRENK (work cited, p. 26), and later on HEDGCOCK (work cited, p. 110) state, with regard to the *Ceratostomella* species that the brown colour of the walls of the hyphæ cannot be extracted, nor any discharge of pigment from the fungi take place. The blue-grey or blue-black colour of the timber attacked must therefore clearly be due to the fact that the hyphæ contain traces of a blue pigment, which seems to be more easily detected through the walls of the cells of the wood than the brown pigment in spite of the latter's

[1] That the intensity of the colour of the mycelium often changes according to the substratum has also been verified by us. A series of culture tests with 10 isolated blueing fungi have been made on nutriment agar with different carbon sources viz: starch, dextrine, maltose, glucose and olive oil. After 5 weeks the mycelium of the *Ceratostomella Piceæ* was still practically entirely colourless, only the submerged hyphæ on maltose had become very slightly browned. *C. cærulea* had a colourless mycelium on dextrine and glucose, a scarcely noticeably tint of light-brown on starch, olive oil and maltose. *C. Pini* had no, or scarcely perceptible, colour on glucose and maltose, whereas in the case of the other carbon sources there were in parts quite considerable brownish stains. *Endoconidiophora* and the tested *Hyphomycetes* had to a great extent the same intensity of colour on the various carbon sources (cf. Table 14).

quantitative preponderance. This supposition, which lacks every support in reality, does not, however, solve the problem in question. The explanation put forward by MÜNCH (1907, p. 533) is entitled to a far greater consideration. According to his theory the blue tint is a pure optical phenomenon and depends entirely on the manner in which the fungus-hyphæ are distributed in the wood. If a dark coloured substance, finely distributed, is placed in a transparent medium, it loses its own colour and takes an another, the form of which depends on the size of the particles. MÜNCH refers to the blue colour which characterizes diluted milk, thin cigarette smoke, and the blue of the sky which is produced by extremely small bodies that are kept floating in the atmosphere which itself is colourless. The more or less blue shades which appear when the yellowish-white sapwood is threaded with fine, dark-brown hyphæ, can undoubtedly be explained in the same way. As a further support of this theory it may be mentioned that MÜNCH (1908, p. 306) in his cultivation of *Ceratostomella Pini* and *C. cœrulea* on starch-paste obtained a very clear blue on the upper parts of the substratum where the brown hyphæ were more sparsely distributed; in the deeper layers, where for some reason the hyphae grew more prolifically, the colour was brown. Analogous conditions may certainly be said to exist when the substratum consists of wood. When the hyphæ here develop to such an extent that the pith-rays and resin-ducts are entirely filled, and they appear on the radial sections as fine black streaks, the blue tinge has vanished, and the colour-scale then shifts more into grey or brown-black.

Before leaving the question of colour it may be worth while to point out that in certain cases a distinct, dark coloration, undoubtedly caused by the fungus, may be noticed on the membranes of the wood-cells. This is most easily observed in pine-timber. As far as we have been able to discover a brown pigment is in realty emitted from the hyphæ, which is uniformly absorbed by the un-lignified parts of the walls of the parenchyma-cells — both in the pith-rays and in the resin-ducts — sometimes also by the membranes in the bordered pits of the tracheids. MÜNCH (1908, p. 301) has also observed a brown coloration of the walls of the parenchyma of the pith-rays, although he considers it to be due to disintegrating products from the cell content.

3. The appearance of blueing in the open and the possibilities of the dissemination of fungi.

In practice two different kinds of blueing are sometimes distinguished: log-blueing and surface-blueing. The former is developed in timber

which has not been removed immediately after felling, or in trunks which have died on the root and involves generally heavier losses, as the bulk of the sapwood may become entirely discoloured in quite a short time. Surface-blueing occurs chiefly on sawn wood in timber-yards, and does not in favourable cases penetrate to any depth and can consequently be removed by proper methods. There is a prevalent idea that two different kinds of damages exist here, or in other words, that different fungi are active in different cases. Even if this may sometimes be the case, the varying extent of the ravages may in the first instance depend on the different conditions suitable for the quantitative development of the fungi.

Such as blueing generally occurs in nature, it gives perhaps in the first instance the impression of being the result of the activity of the saprophytic forms of fungi in a dead substratum, and in the majority of cases this is, possibly, also correct. Nevertheless, MÜNCH (1908, p. 32), has been able to determine by his comprehensive inoculation-tests that the mycelia are also able to penetrate into live wood and kill its parenchyma cells, provided the necessary conditions exist. The character of the wood, whether living or dead, does not actually play any decisive part in the matter of determination, but a certain reduction in the moisture content and a simultaneous increase in the interior volume of air are important factors in this connection. A trunk which is felled during the winter keeps its parechyma cells alive far into the following summer, provided the bark is allowed to remain on it so that desiccation does not set in too rapidly. A continuous loss of moisture, however, soon gives the fungus a chance of entry and it is therefore pretty certain that it must be characterized as a parasite in its early stages of existence in the wood. MÜNCH (1908, p. 297) infected 30 to 40-year-old growing pines and spruces with pure cultures of his blueing fungi. He tried to reduce the moisture content of the trunks partly by cutting away the surface roots and partly by sawing through the sapwood on one side of the trunks at two levels with about half a metre mutual distance. Two pines were treated in the latter way, and the part of the trunk between the saw-cuts was infected; after 6 months the sapwood had become blued, right through, and the blueing had, moreover, developed below the lowest cut for a distance of about 20 cm. As the result of this test MÜNCH also asserts that it is possible for the blueing fungi, under certain circumstances, to be the direct cause of the death of a pine tree.

As this question is undoubtedly of great interest, we wish to draw attention to a similar test which was made by WILSON (1922, p. 88) in

England, and with identical results. The roots of a pine were cut through, entailing a decrease in the normal moisture of the trunk. On another tree the bark and the sapwood were completely sawn through in two places, one 18 inches higher than the other. The part of the trunk which was thus cut off from its water supply was infected and it blued very perceptibly. In the tree with the roots sawn off, which had likewise been infected, blueing developed in the inner part of the sapwood, presumably owing to the fact that the moisture content had decreased sufficiently in that portion of the wood.

In nature such occurences are no doubt frequent, e. g. ravages by the wind, injuries to the roots of the tree, which may entail similar effects as those described in the above-mentioned tests. There is also another form of injury which is of no mean importance as the basis of blueing in the live trees, namely the attacks of bark-boring beetles. In North America VON SCHRENK (work cited) has been able to prove that *Dendroctonus ponderosæ*, which is one of the more powerful of bark-beetles, was the direct cause of blueing in growing *Pinus ponderosa*. Only three weeks after the attack by this beetle distinct traces of blueing could be observed in the immediate area of the galleries, and after another three months the lower part of the trunk was very much stained right though, whilst the trees were otherwise unchanged. One may assume that in other places, too, bark-beetles are the cause of blueing on trees on the roots. As a matter of fact, we have had no opportunity ourselves of making any direct observations in this connection. From England, however, there is an account (MAC CALLUM 1922, p. 232) of an attack by *Ceratostomella Piceæ* and *C. Pini* on growing pines, and in each case the bark was full of the galleries of the large pine beetles *(Blastophagus piniperda)*.

As a further example the importance of external injuries for the appearance of blueing in live trees it may here be mentioned en passant that *Endoconidiophora cœrulescens* has shown that it can easily penetrate into blazed spruces which have been allowed to remain standing for a few years after blazing. The same possibilities exist also in the case of another fungus, *Discula pinicola*, of which a more detailed account will be given later. In both cases intense blueing has developed in the live sapwood and has spread rapidly both upwards and downwards, with the blazed spot as a starting point.

From the discoveries already made one may consider that it has been proved that several of the blueing fungi have the power to penetrate into the living wood and kill its parenchyma cells. As far as one can judge this circumstance must entail a very evident risk to

growing trees, and it is not excluded that these fungi contribute largely to their death, when this, for example, is considered to be entirely the result of an attack by the pine beetle.

The discovery that blueing very easily appears in connection with bark-beetles has given rise to the thought that these insects are the direct carriers of infection. They are probably also the chief agents for carrying the spores of the *Ceratostomella* species. On ripening they lie embedded in mucus and are thus forced out through the perithecium opening where they accumulate into a growing spherical mass. When this has reached a certain size, it can, however, not remain in its original terminal position but begins to move down along the neck of the perithecia on which it forms irregular lumps (cf. fig. 24 *a*). The mucus does not dissolve in water and a dissemination of the spores can therefore only take place when these are attached to some contiguous object. FALCK (1916) seems to reckon with the possibility that the dissemination might also occur endozoically, and he imagines that mucus would protect the spores in their passage through the animals' alimentary canal. The case of the *Endoconidiophora cærulescens* has given us a direct opportunity of proving that the nutritious spores are actually consumed by insects. For instance, some small beetle larvæ were discovered on a slab of wood which had a dense covering of this fungus, and these were, slowly browsing on the masses of sac-spores and chains of conidia thus confirming the belief that these were the coveted food of the larvæ. It is even conceivable that the full-grown insects also devoted the same attention to them. There are, however, no very great prospects of the exceedingly thin-walled spores, and still less of the conidia, being of any value as a means of infection after they have passed through the alimentary canal of an insect. The dissemination in that case would almost certainly have to take place epizoically.

FALCK considers that running water is the principal means for disseminating the *Ceratostomella* conidia, chiefly because of the ease with which a collection of conidia are dissolved and dispersed when brought into contact with water. This may be all very well, but when the same author later on also asserts that no kinds of spores of blueing fungi are disseminated by the aid of the wind, he is clearly guilty of an oversight. If we were not able to count upon dissemination by the wind, it would be rather difficult to understand the speed with which blueing develops everywhere when conditions are propitious for it. In reality the *Ceratostomella* species possess just by their profuse conidia, formed direct on the air-mycelia, propagation bodies which are adapted for dissemination through the air, and it is undoubtedly these very

conidia that form the most effective distribution units for these fungi. The wind must also, of course, be the chief disseminator of the numerous *Hyphomycetes* which develop conidia profusely on the surface of the attacked pieces of wood. It is more difficult to explain how mycelia, which under all circumstances remain sterile in culture, can nevertheless possess such possibilities of infection. It is, of course, conceivable that the formation of the conidia can occur in such fungi in the open under conditions which we have not succeeded in imitating in the laboratory, but one may also assume that it is possible for the logs to be directly attacked by the mycelia from the ground, where the fungus in that case must be growing. It does not seem to us improbable that the foundation of the so-called log-blueing many a time can be traced to such forms. One must also assume that blueing fungi in closely stacked timber may be transplanted direct from one log to another through the contact surfaces. For example, it happens not infrequently that the solid pillar of wood, which is formed at the corners of the stack by the cross-wise piling up at the contact surfaces with the stickers, from the bottom right to the top is intensely blued whilst the planks are otherwise undamaged. Here, the close contact between the compressed boards undoubtedly affords the mycelia a direct passage, although, of course, there is always the possibility that all the boards were infected before being stacked.

4. Swedish blueing fungi.

A. Species of Ceratostomataceæ.

As has previously been mentioned, there are at the present time no forms of blueing fungi which have been so thoroughly investigated as those belonging to the genus *Ceratostomella*. Their perithecia, which are as a rule located quite superficially, are jet-black to the naked eye, but brown-black under the microscope; their consistency is brittle. The ventral part containing spore-sacs is more or less globular and has a pseudoparenchymatous peridium. The development of the neck begins quite early and tit grows into a narrow tube, which in several species attains a length which many times exceeds the diameter of the ventral part. The neck is built up of a single layer of parallel, longicellular hyphæ. The separate cells are, however, not easy to distinguish on account of the thickness and dark colour of the membrane. During the growth the hyphæ at the cerevical apex are united into a dome (cf. fig. 10 *a* and 15) and colourless, but on the ripening of the perithecia

they become detached from one another, and the extremely thin-walled hyaline points are bent outwards like a fringe of cilia round the small neck-opening. The issuing mass of spores is temporarily caught on these cilia, to which HEDGCOCK, in his aforesaid investigation, paid a considerable attention. As might be believed from his drawings they do not, however, consist of only one cell but of a row of cells, but on account of their extraordinary minuteness the transversal walls are not always easy to discover.

The ventral part of the perithecia in all the species examined by us is characterized by a more or less luxuriant hirsute covering. The hairs consist of single rows of brown cells and are usually irregularly flexed. We have never come across entirely bare perithecia, at any rate live ones which, according to statements in literature, are said to occur. It is quite conceivable that the hairs on the older perithecia may have worn off. In many cases the hairs begin to grow very early, even long before any sign of a neck can be observed. The young fruit-bodies then display a decided similarity to the perithecia in mildew-fungi. It should be noted that the growth of the hairs on the ventral part is restricted, and that they do not form part of the superficial myceliar substratum. HEDGCOCK (work cited, pl. 5, fig. 6) has given a figure of the *Ceratostomella minor*, from which we can gather such an impression, which certainly does not agree with the fact.

We find the earlier stages of the perithecia plentifully developed in the agar cultures, and on sufficiently thin plates we can also study some of their details in the microscope. In all the *Ceratostomella* species which we have examined, there appears a more or less distinct, spiral-shaped coil of hyphæ, which soon develops into a tight hank of a more rounded shape. MÜNCH (1907, p. 570, fig. 25) describes and illustrates corresponding stages in the *Endoconidiophora cærulescens*, but does not venture to give any definite opinion concerning their significance. In our opinion, these illustrations, however, convey the idea that at an early stage of development a fertilization occurs of a type already known for several *Ascomycetes*. We also find all transitory stages between the hypha coils and the fully ripe perithecia. Our researches have, however, not been made with a view to obtain any very accurate information on the features of fertilization, and we therefore restrict ourselves to what has so far been referred to in this connection.

The content of the perithecia in all the *Ceratostomella* species are extremely difficult to observe. In its unripe state it contains large quantities of fat which easily exudes if the fruit-body is crushed under the cover-glass. The spore-sacs are extremely small and are not

accessible for examination when they are ripe, for the simple reason that their membranes are converted into mucus and disintegrate as soon as they come into contact with water. They can, however, be squeezed out of unripe perithecia, and one can in this way prove that they are round or slightly pear-shaped. We have been unable to discover the polyhedral type which MÜNCH (1907, p. 538) mentions and also illustrates. The number of spores is generally about 8. Not infrequently one finds loose lots containing 8 spores in the slides, and these clearly retain the mutual position which they have occupied within the spore-sac. MÜNCH asserts that the number of spores may also be 6. On ripening the spores released from the sacs are embedded in mucus and are easily pressed out in the slides with this in the shape of a white sinuous filament which does not dissolve in water. As has previously been mentioned, the issuing mucus is formed into a ball in the air. The unicellular, colourless, very thin-walled spores possess a manifestly uniform type for all the species of the group in question. They certainly vary somewhat in size, but one can scarcely deduce any useful characteristics of species from them. They are shaped like the sections of an orange — not cylindrical with rounded apices as MÜNCH (1907, p. 547) states — and thus they possess only 2 symmetrical levels. Sometimes the usually straight ventral side may be slightly concave.

The great external similarity displayed by the perithecia of the various species makes it difficult to base an accurate definition of the species solely on them. Such an attempt has, however, been made by HEDGCOCK who for this purpose principally takes into consideration the development of the terminal fringe of cilia. He has observed that there is a certain dissimilarity in the length and thickness of the cilia in the various species. Unfortunately, the illustrations of these details, which are to be found on Plate 3 of his above-mentioned work, are not very convincing. For they are so incompletely drawn, that on comparison it is difficult to realise that the alleged differences actually exist. MÜNCH (1907, p. 540) has also noted this obvious defect and asserts, as previously mentioned, that the species set up by him possess no systematically practicable characteristics in the formation of the fringe of cilia. These contradictory opinions have induced us to devote special attention to this question, and as a result of our investigations we have come to the conclusion that as regards the systematic importance of the cilia HEDGCOCK seems to have been on the right road. Even the species within the *pilifera*-group, established by MÜNCH, possess good characteristics in their cilia. In this connection the reservation should, however, be made that we have not come across, and thus have not

been able to investigate, *Ceratostomella cana* Münch, but in its stead one of HEDGCOCK's species, *C. pluriannulata*, which must also be placed in the above group. According to the species differences assuredly exist both in the form of the cilia, and their number, which latter does not appear to have been noticed by earlier writers. In a future revision of the genus *Ceratostomella* it will therefore be a sine qua non that these points of view are duly considered. Even if the characteristics of the cilia are no deciding features in themselves, they nevertheless afford a good guidance towards a definition, unless an opportunity presents itself for examining the other reproductive stages of the fungi.

MÜNCH (1907, p. 538) has given a very comprehensive statement concerning the change of form exhibited by the conidial stages in the *Ceratostomella* species. In all those examined the conidia are formed direct on the mycelium, but the type varies considerably, which partly depends on the kind of substratum on which the fungus is grown. In nature the types are probably less pronounced. MÜNCH distinguishes as follows: 1. the *Cladosporium*-type; 2. a type with the conidia in terminal head-like agglomerations (characterized by HEDGCOCK as the *Cephalosporium*-type); 3. a type which most closely resembles the genus *Sporotrichum* with a ear-like arrangement of the conidia. The first-named type consists of upright, racemously ramified, sparse conidial clusters (cf. fig. 16 *d*), in which chains of cells of up to 3 different orders can be discerned. The ramification thus reminds one very much of that characteristic for the genus *Cladosporium*. In these systems of ramification, however, not only the terminal cells are conidia. The whole system of ramification can drop to pieces and then even cells which formed part and parcel of the basal portions of the branches become isolated and function as conidia. This circumstance entails that very great variation may occur both in regard to the size and the shape of the conidia, and the particulars concerning measurement therefore become of little value for the identification of the species. The *Cladosporium*-type, moreover, varies quite considerably, and is through intermediate forms linked to the *Cephalosporium*-type. The last-named glides in its turn smoothly over into the ear-type. As a further form of conidial formation MÜNCH mentions the budding displayed by the conidia after having been isolated. Possibility of budding apparently occurs in most blueing fungi, although in nature this may not exist to any great extent. In pure cultures on malt-agar, however, it becomes many a time of such importance that colonies are developed into sticky porridge-like masses in which the original air-mycelium entirely disappears. MÜNCH seems to consider lack of nourishment in

the substratum as a condition for the occurrence of budding. Our experimental cultures, however, hardly support this theory. We are more inclined to believe that budding is most intense when the fungus is growing strongly.

MÜNCH's discovery that the genus *Graphium* of the *Stilbaceæ* comprizes conidial stages of the genus *Ceratostomella* must be considered a remarkably interesting result of his studies of the blueing fungi. As a matter of fact, in *C. Piceæ* the occurrence of a graphium (together with myceliar conidia of *Cephalosporium*-type) is the foremost characteristic to distinguish it from *C. cærulea*, to which it is so closely related. The accuracy of this statement was subsequently confirmed by MAC CALLUM (work cited, p. 233—234). Our cultures have also shown that a genetic connection exists between *C. Piceæ* and a graphium which, besides, appears to be very common in nature. It may be questioned whether this connection might not entitle *C. Piceæ* to a more independent position just as *Endoconidiophora cærulescens,* which MÜNCH has set up as a type for a separate genus on account of its remarkable conidial stage (*Chalara Ungeri*). The unnamed North American forms, which, according to Miss RUMBOLD (1911), also possess a graphium as a conidial stage ought in that case to be grouped with *C. Piceæ* as well as *C. cana* Münch. However, it would perhaps not be advisable to separate all these species from the genus *Ceratostomella*, inasmuch as their myceliar conidia indicate close kindred with it.

In HEDGCOCK's work on the wood-blueing fungi the genus *Graphium* occupies, as mentioned, a fairly prominent place.. He classifies the 7 more minutely described forms according to the shape of their so-called secondary conidia which are developed direct on the mycelium. To judge by the appended figures, this simpler conidial stage displays in a couple of species, *G. album* and *G. aureum*, almost entire agreement with the *Cladosporium*-type occurring in the genus *Ceratostomella*. Probably HEDGCOCK has come across *Ceratostomella* graphia in these forms, although his pure cultures have not induced him to consider such a possibility. It is worth pointing out that on the wood of the *Pinus echinata*, from which HEDGCOCK isolated his *Ceratostomella Schrenkiana*, a graphium as well as some other *Hyphomycetes* occurred. During the experiment with *Graphium aureum* he found it necessary to adopt all precautionary measures for confirming the relationship between this fungus and a secondary conidial stage, which had aroused the suspicion that the culture might have been corrupted by some *Ceratostomella*. It is certain that HEDGCOCK was very near to discovering

the relation between this genus and *Graphium*. The reason of his failure may possible have been that the perithecia which are the decisive features may sometimes remain absent in the cultures. Such an experience has been made by several investigators in regard to *Ceratostomella Piceæ*, and such a case needs really not be unique.

Such as the genus *Graphium* has been interpreted in literature, it does not seem to be uniform. To judge by the conidial formation it also contains forms with another relationship than the above-mentioned. We do not mean by this to refer to BOULANGER's (1895) attempt to link up *Graphium* with *Chætomium cuniculorum*, a pyrenomycete of a quite different group. It may reasonably be doubted that this conclusion is correct, (cf. RUMBOLD 1911, p. 450). When perusing BOULANGER's description, and studying his illustrations (Pl. 5), one must feel doubtful about his identifying the pyrenomycete investigated. The sketches show rather that he had *Ceratostomella Piceæ* before him and that the perithecia reproduced might well belong to this species, if we assume that their necks have been broken off. They certainly do not belong to the genus *Chætomium*. We must, however, not overlook the fact that the text contains statements — for example concerning the shape and colour of the spores — which contradict the interpretation suggested by us.

Ceratostomella cœrulea MÜNCH.

This species has been taken in pure culture from the following districts:

1. Dalecarlia, Garpenberg 26. 11. 1923. From pine-timber included in the storage tests.
2. Dalecarlia, Dalfors, Kopparberg-Hofors' forests, 30. 3. 1925. From summer-felled pine pulp-wood stored in the forest, together with *Ceratostomella Piceæ*. Material obtained from Mr ERNST ANDERSSON.
3. Västmanland, Bjurfors, Aug., 1925. From sawn pine-timber together with *Hormonema dematioides*.
4. Ångermanland, Svanö, Aug. 1925. From sawn pine-timber, both alone and together with *Hormonema dematioides*.
5. Värmland, Ransäter, 11. 9. 1925. From slabs taken from spruce-logs felled during the summer, together with *Endoconidiophora cœrulescens*. Material obtained from Mr S. JOHANSSON.
6. Värmland, Skoghall Works, Nov. 1925. From sawn pine and spruce-timber.

Our further observations of this species in nature, which have, however, not been verified by pure cultures laid down, indicate that it is widely disseminated.

On malt-agar the fungus forms a compact, light-grey air-mycelium which soon changes into a luxuriant conidial growth. The mycelium becomes a maze of filaments which may, perhaps, best be likened to barbed wire-netting and these fibres appear quite flourywhite through their conidia (fig. 1). The under-side of the colonies is greenblack in colour. Their rate of growth[1] is 3,5; their development regularly centrifugal (fig. 2). The mycelium emits a clearly noticeable, acid smell.

The air-mycelium grows on wood in the same way as on malt-agar,

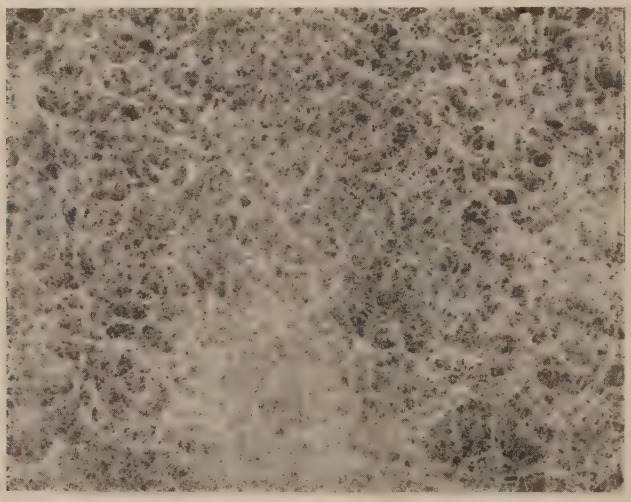


Photo by T. Lagerberg.

Fig. 1. *Ceratostomella cærulea.* Retiform development of the air-mycelium. Pure culture on malt-agar (× 12).
Luftmycelets nätlika utformning. Renkultur på malt-agar (× 12).

and the discoloured surface of the wood is often greenish-grey throughout. By comparative tests it has been proved that the fungus develops more strongly on pine than on spruce.

Perithecia appear in profusion on practically all substrata, although with slightly different rapidity. In cultures from freshly isolated strains they appear already after about ten days; in cultures from older strains the development of perithecia remains entirely absent. Development is slower on wood; after a month, however, the surface of the wood is covered with numerous, fully-grown perithecia. Their form is very characteristic and scarcely varies at all (fig. 3). The ventral part is not

[1] The rate of growth means the radial growth in cm. during 10 days at + 22° Centigrade, thus in this case 3,5 cm.

quite globular but slightly flattened; the diameter at the equator thus exceeds the height. The measurements have shown that there is a great deal of variation in size. In the largest perithecium tested the ventral diameter measured 288 μ, with a corresponding height of 240 μ; in the smallest the corresponding figures were 160 and 144 respec-

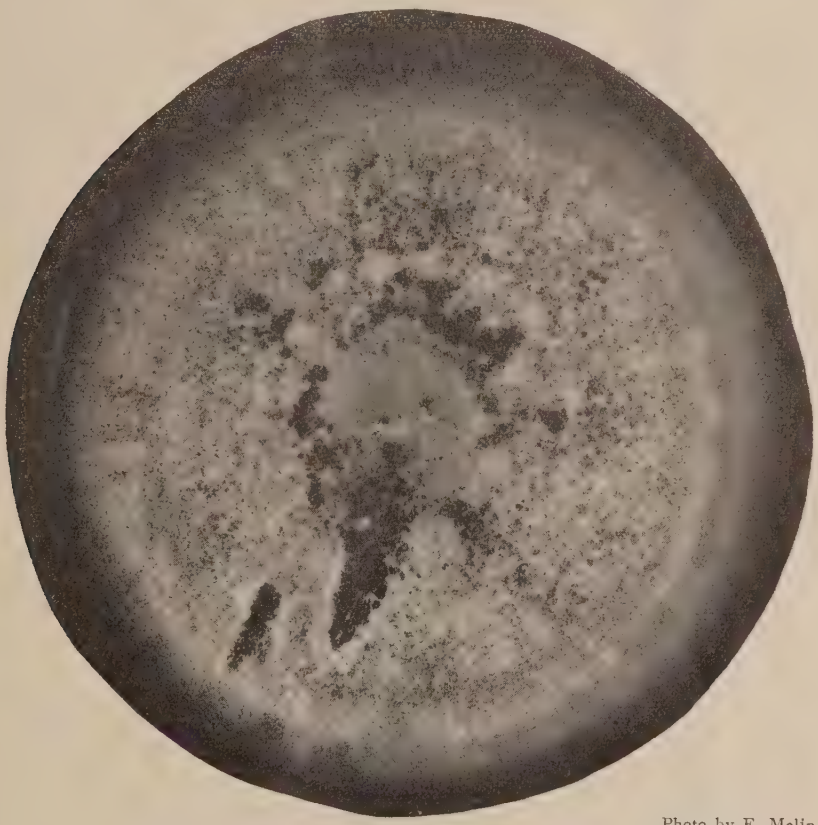


Photo by E. Melin.

Fig. 2. *Ceratostomella cærulea.* Pure culture on malt-agar (× 1,3).
Renkultur på maltagar (× 1,3).

tively. The relations between width and height are certainly not always the same, but the variation is only slight. The ripe perithecia have fairly numerous ventral hairs whose thickness is about 3,5 μ; the length varies greatly, e. g. 143 μ and 40 μ on the same perithecium. The sharply marked necks, almost cylindrical at the lower part, attain on large fruit-bodies a length of 1,5 mm., the average length being 1 mm., not including the fringe of cilia. As a rule we find longer necks on larger perithecia, but the relation is not very definite. A

Fig. 3. *Ceratostomella cærulea.* Ripe perithecium × 100. Pure culture on malt-agar.
Moget perithecium (× 100). Renkultur på maltagar.

the base the necks measure about 30 μ, under the fringe of cilia the measurement varies between 19 and 16 μ. Smaller protuberances and inequalities on the necks are not uncommon.

The average number of cilia is 24, their thickness at the base is 2 μ, and under the bluntly rounded apex 1,6 μ. The angustation is therefore quite insignificant, a characteristic distinguishing *C. cærulea* from the closely related *C. pluriannulata*. The length of the cilia varies rather considerably — the measurements obtained vary between 100 and 35,7 μ — and, moreover, different lengths are very often found in the same fringe of cilia, e.g. 85,7 μ and 46,4 μ (fig. 4). We have not observed such a great disparity in length in other species of this genus. Maybe the objection is raised that the different conditions of culture might possibly be the cause of this irregularity, but it should then be noted that other species have been cultivated in exactly the same way. The great variation in length may possibly be due to some of the cilia growing more vigorously than others after the opening of the neck apex, when all are of equal length.

The spores belong to the above-mentioned type. Their length varies between 3,7 and 4,7 μ, and their thickness between 1,5 and 1,9 μ.

Abnormal perithecia are not infrequently met with. As a manifest deviation may be mentioned the occurrence of several necks; 2 and 3 have been observed, but possibly still more may occur. At the same time the ventral parts of the perithecia were of the usual size and not subdivided internally, which proves that no coalescence of originally separate inceptions can have taken place. In this connection it may be of interest to note that FUCKEL (work cited, p. 129, Pl. IV fig. 41) has described as a new species *(Ceratostoma multirostratum)* a

form in which, besides the single-necked perithecia, there often occur such possessing 2—6 divergent necks. It is not improbable that this new species was founded on a similar temporary divergence as the one we have observed. This supposition gains in probability as perithecia with a surplus number of necks also appear in other *Ceratostomella* species, e. g. in *C. Piceæ* (cf. fig. 10).

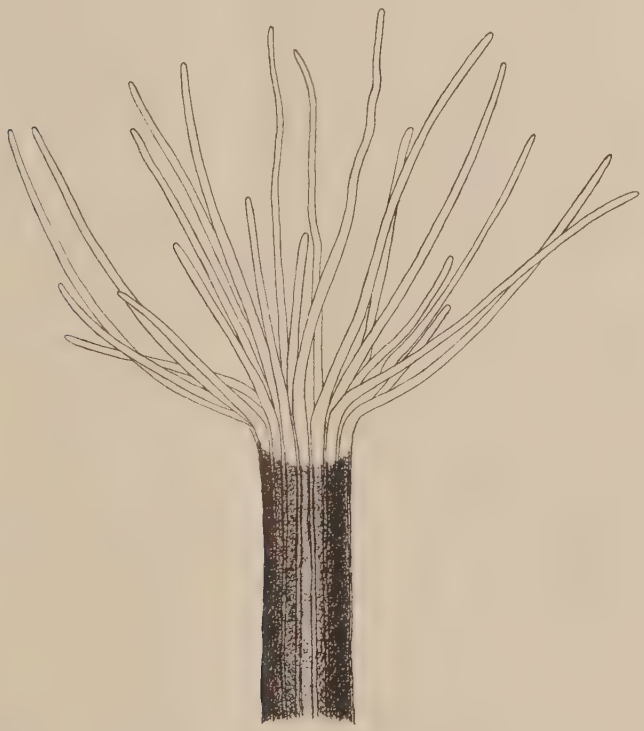


Fig. 4. *Ceratostomella cærulea.* Fringe of cilia (× 630). Pure culture on pine-wood.
Ciliekrans (× 630). Renkultur på tallved.

Another remarkable deviation which, however, is probably of more rare occurrence — we have observed it only once in an agar culture — has already been described by MÜNCH (1907, p. 564). When he cultivated *C. cærulea* on wood he obtained perithecia with several fringes of cilia besides the terminal one, two more occurring lower down on the neck. MÜNCH considers it probable that HEDGCOCK established his new species, *pluriannulata*, upon such perithecia. It is just the occurrence of several fringes of cilia which form an integrant part of his diagnosis. It is, however, quite evident for several reasons that *C.*

pluriannulata must be regarded as a species quite distinct from *C. cœrulea*, of which more hereafter. The explanation given by MÜNCH of the appearance of the surplus fringes of cilia may possibly be disputed, but he certainly draws an unjustified comparison when he wishes to see in this development an analogy to the »proliferating» graphia which are sometimes found in *C. Piceæ*.

As has been mentioned, the conidial stages of the fungus very soon make their appearance in the cultures. The type we have found most frequently is the one similar to the *Cephalosporium*, but it very often shows a tendency to develop like the *Cladosporium* (fig. 5 *a*). MÜNCH (1907, p. 562) describes the latter in a purer form as common and also illustrates a greatly ramified conidial tree, in which branches of up to the third order may be distinguished. These systems of ramification in *Ceratostomella cœrulea*, according to the same author, do not disintegrate so easily as in *C. Piceæ*. We have, however, not been able to discover any actual difference between the two species in this respect. In water instant disintegration of their conidial clusters occurs. Consequently the free conidia found in the slides display rather a varying size (fig. 5 *b*). The length varies between 5,6 and 11,2 μ, and the thickness between 1,9 and 3,7 μ. An increase in length is not

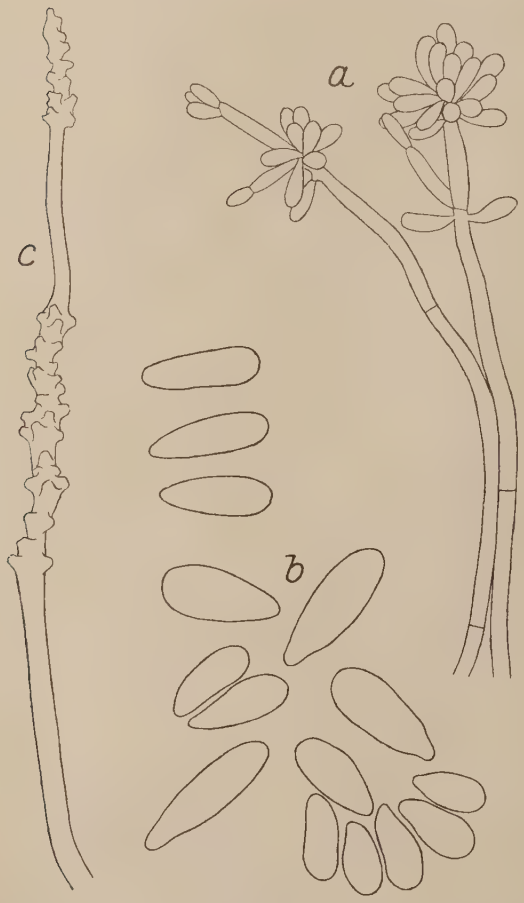


Fig. 5. *Ceratostomella cœrulea*. *a*. Terminal, head-like conidial cluster (*Cephalosporium*-type) and transition-form to the ramified *Cladosporium*-type (× 1125). *b*. Conidia (× 2175). *c*. Hypha which has borne ear-shaped conidial collections (× 2175). — Pure culture on malt-agar.
a. Terminal, huvudlik konidieställning (*Cephalosporium*-typ) samt övergångsform till den grenade *Cladosporium*-typen (× 1125). *b*. Konidier (× 2175). *c*. Hyf, som burit axlika konidiesamlingar (× 2175). — Renkultur på maltagar.

always accompanied by a corresponding increase in thickness. The usual form can therefore be characterized as an more or less elongated pear-shape, tapering pretty considerably towards the end at which it is attached. After the conidia are isolated strong budding commences; we have not been able to determine if this also happens when the fungus is growing on wood.

Perhaps the most characteristic form of the conidia in the *Ceratostomella cærulea* is that shaped like an ear. It may be regarded as a further development of the head-shaped form which is found in masses both on malt-agar and on wood. Great difficulties were, however, encountered in getting perfect conidial ears under the microscope for examination. The conidia dissolve immediately in water, but the fructiferous branches of hyphæ are easily discernible through the densely agglomerated, lug-shaped projections appearing at longer or shorter intervals from which the conidia have emanated. The ears are sometimes grown right through in order to repeat themselves on the other side (fig. 5 *c*) and at times are also scantily ramified. Their conidia are, as a rule, somewhat shorter and of more uniform size (fig. 5 *b*, lowermost) than those which appear in conidial clusters of another kind.

The development of the fungus in timber has been investigated in pine and spruce sectors upon which it has been inoculated under sterile conditions. The methods employed in these pure cultures are dealt with in detail hereafter. In this connection we only intend to record a few observations on the morphology and manner of growth of the mycelium in the tissues of the wood, and the changes which occur when the fungus is present. The same particulars are also given fo the species which are dealt with later on, from which it may be seen that also from this valuable data are to be obtained for a diagnosis of the respective species. It has, however, been found impossible to determine the species of a blueing fungus merely by the aid of the mycelium; moreover, this question has been raised too soon, inasmuch as our knowledge of all the forms which produce blueing is still incomplete.

C. cærulea belongs to the more active blueing fungi. In pine-wood it produces an intense, almost blue-black, discoloration; in spruce the stain is fainter and less extensive (Plate I). It is obvious that spruce as a rule seems to constitute a less favourable substratum for blueing fungi. On a piece of pine-wood in which the fungus has reached its maximal development, the pith-rays on the radial section are discernible to the naked eye as brown-black ribbons, and the vertical resin-ducts appear as fine lines drawn in Indian ink. The rows of parenchyma cells of the pith-rays are discernible in the microscope as more

or less completely replete with fairly parallel hyphæ which, however, locally display an irregular, sinuous course. In one or two instances we have noticed that the hyphæ during their earlier development in the wood formed spherical, compact hanks in the parenchyma cells, and by their regular distribution these attracted special attention (fig. 6). It was found that only one had formed in each parenchyma cell, and it was quite evident that the nuclei of these cells were the centres of attraction for the collections of hyphæ. Nor is this impression contra-

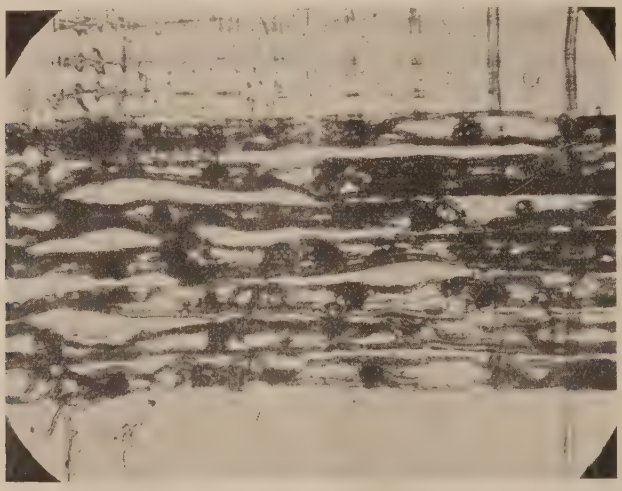


Photo by T. Lagerberg.

Fig. 6. *Ceratostomella cærulea*. Pith-ray in whose rows of parenchyma cells, isolated from each other, globular collections of hyphæ have developed (× 115). Pure culture on pine-wood.

Märgstråle, i vars från varandra isoleradè parenkymcellrader utbildats bollformade hyfsamlingar (× 115). Renkultur på tallved.

dicted by our experience as regards the nutriment physiology of the blueing fungi which will be discussed later.

In the course of time the membranes of the hyphæ assume a darker brown hue and finally become rugose on the surface. The formation of the cell is of interest in one respect. In those rows of hyphæ which are composed of long cells, the same are usually single, sometimes several in succession, elongated claviform, and swollen towards the end which points in the direction of the apex of the hypha. In agar-cultures this detail can easily be studied on account of its common occurrence, and it is also repeated in wood under identical forms, although, as it seems, not quite so frequently. Our investigations have proved that the same type of cell is also developed in other species of the

genus *Ceratostomella* (cf. fig. 11 *f*),whilst it is totally absent in the other blueing fungi which we have studied. It is therefore not unlikely that we must acknowledge the same as a characteristic of more than casual significance.

In the pine the parenchyma cells of the pith-rays re-act in rather a

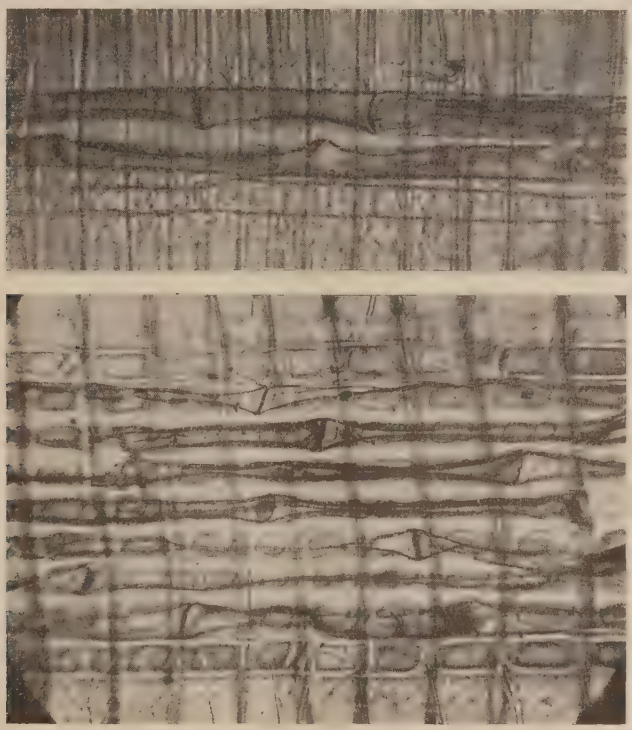


Photo by T. Lagerberg.

Fig. 7. *Ceratostomella cærulea*. Pith-rays with contraction phenomena in the parenchyma (× 115). *a*. 2 rows of parenchyma cells, mutualy isolated but still in contact with contiguous rows of marginal cells. *b*. 9 rows of parenchyma cells with hour-glass shaped contractions. Pure culture on pine-wood.

Märgstrålar med kontraktionsfenomen i parenkymet (× 115). *a*. 2 parenkymcellrader, inbördes isolerade men fortfarande i förbindelse med tillstötande trakeidala cellräckor, *b*. 9 parenkymcellrader med timglaslika kontraktioner. Renkultur på tallved.

curious manner against the intrusive fungus mycelium. The form of the cells is altered in connection with the destruction of the cell-contents, although in somewhat different ways, according to the structure of the pith-rays. In those containing only two rows of parenchyma cells they become detached from one another, while each one remains in unchanged contact with the adjoining marginal cells (fig. 7 *a*). In

pith-rays which are higher, and consequently contain a larger number of rows of parenchyma cells, the upper and lower row behave in the same manner, while the intermediatie ones which become detached from one another, are constricted like an hour-glass (fig. 7 *b*); the direct cause of this change is the transversal walls which are common for two parenchyma cells and resist constriction. When this constriction has been carried to the utmost, the isolated rows of parenchyma cells almost give the impression of a pearl necklace.

In the parenchymatous vaginæ of the vertical resin-ducts and in their cavities we find a profusion of hyphæ. But on the other hand they occur comparatively sparsely in the marginal cells and in the tracheids. They do not form any compact masses here but grow in isolated and narrow stretches (thickness about 5 μ). They penetrate lengthwise through the tracheids, and grow through the bordered pits without changing their periclinal direction in any respect, but they also possess the faculty of boring right through the thick walls of the tracheids. One finds hyphæ everywhere on the radial sections, and these cross the tracheids at longer or shorter intervals without changing direction, and in so doing perforate the tangential, non-porous walls. Penetration occurs obviously in such a way that the apices of the hyphæ on coming into contact with the wall swells and forms a kind of adpressorium from which a very fine tube grows out direct through the wall. One gets really the impression that perforation takes place mechanically, and that consequently the wall gives way to locally increased pressure. At all events, no dissolution of the wall such as is caused by enzymatous action characteristic of the decaying fungi proper occurs. When the fine perforator has pierced through it swells instantly into the normal width of the hypha and may occassionally exceed the latter (fig. 8).

The capacity of the *Ceratostomella* hyphæ to perforate the tracheid-walls of the conifers direct is not unknown and has previously been dealt with in literature. HUBERT especially (1921, p. 218) has devoted a great deal of attention to this question. He renders a detailed account and gives illustrations of a case where one and the same hypha could be followed through no less than 64 tracheids in wood of *Thuja occidentalis*. The interpretation he gives of the course of perforation itself is, however, hardly correct. In his opinion the growing apex of the hypha discharges a wall-dissolving enzyme, and the width of the holes caused would approximately correspond to the size of the young hyphæ. The swellings on the wall should therefore be a secondary stage. This opinion is, however, contradicted by the fact that the free hyphæ of the extraordinarily small size which characterizes the perforating portions

do not occur. Even the youngest hyphæ in the tracheids or the parenchyma cells must in comparison with these portions be described as vigorous. We must on this account consider that the explanation of the course of perforation which we have given above, is more approaching to accurracy.

The aforesaid penetration of the tracheid-walls is also mentioned by MÜNCH (1907, p. 542 fig. 2; 1908, p. 201) with regard to *Ceratostomella*

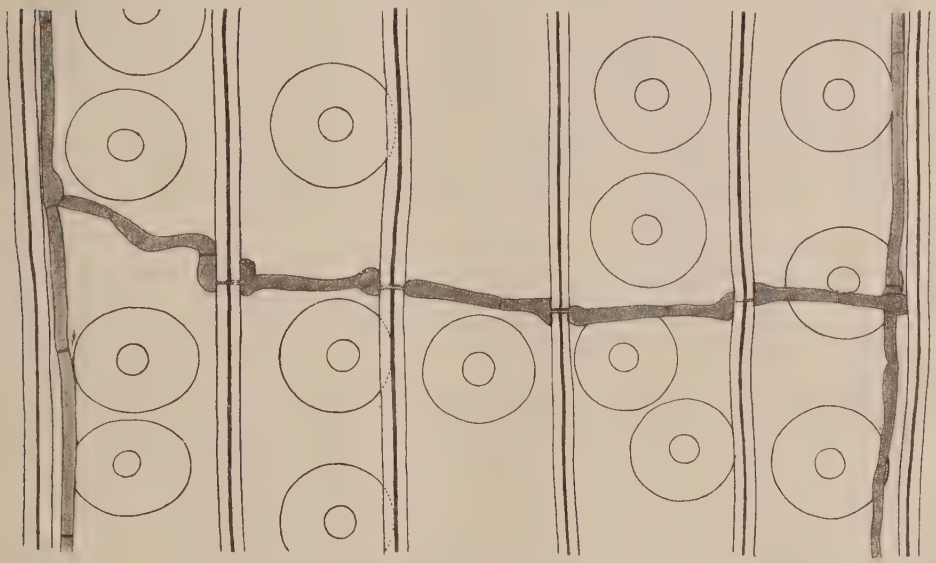


Fig. 8. *Ceratostomella cærulea.* Perforations by a hypha through tracheidal walls in pine-wood (× 630).
Hyfperforationer genom trakeidväggar i tallved (× 630).

Pini. It seems to us, however, uncertain if the hyphæ in this species are equipped with the power of perforation (cf. p. 195).

Our attemps to infect spruce with *Ceratostomella cærulea* have led to varying results. The discoloration caused has sometimes been faint and strictly limited (Plate I), in other cases the sapwood in the inoculated sector has been coloured throughout to a very great extent, but the colouring is faint. The pith-rays appear as greyish-brown bands on the radial surfaces, and under the microscope one sees them intersected by fine light-brown hyphæ which here and there are tightly packed together. Entwined and irregular short-branched hyphæ, with fine, brown membranes, occur in the tracheids, and also straighter and longicellular, almost hyaline ones. The radial perforations are met with everywhere. It is obvious that the fainter blueing is connected

with a fainter colouring of the hyphæ, and the latter in its turn is undoubtedly associated with the conditions of nutriment which spruce-wood has to offer.

Ceratostomella Piceæ MÜNCH.

This species has been discovered in the following districts:

1. Uppland, Lidingö, 1924. On pine, felled during the winter of 1924.
2. Västmanland, Bjurfors, 5. 8. 1924. On pine fire wood cleft and stored in the forest during the previous winter. On the colourless wood surfaces masses of graphia and perithecia.
3. Dalecarlia, Torsång, Dec. 1924. Floated pine and spruce-timber, obtained from Dalecarlia's Timber Floating Association.
4. Dalecarlia, Dalfors, Kopparberg—Hofors' forests, 30. 3. 1925. On summer-felled pine pulp-wood stored in the forest, together with *Ceratostomella cærulea*. Material obtained from Mr ERNST ANDERSSON.
5. Västmanland, Bjurfors, Aug. 1925. On spruce trunks which had been lying cut in the forest for a year. The surface black with closely packed graphia and perithecia; blueing, however, slight.
6. Ångermanland, Svanö, Aug. 1925. On sawn spruce-timber, together with *Hormonema dematioides* and *Cadophora fastigiata*.
7. Ångermanland, Kramfors, Sept. 1925. On sawn spruce-timber, alone and also together with *Cadophora fastigiata*.
8. Värmland, Skoghall Works, Nov. 1925. On sawn spruce-timber, alone, together with *Cadophora fastigiata* and also together with the latter and *Penicillium biforme*.
9. Värmland, Uddeholm, 23. 11. 1925. On timber sawn during July and August 1925. Graphia on 4 of the 10 pine-boards and on 8 of the 10 spruce-boards examined, in both cases on the blued as on the colourless parts.
10. Gästrikland, Bomhus, 23. 11. 1925. On spruce-timber, sawn in July 1925; numerous graphia on the 6 boards examined.

Ceratostomella Piceæ very often occurs in nature closely intermixed with *C. cærulea*, and it is quite possible that even now we should not have known them as separate species if not MÜNCH (1907, p. 561) had succeeded in pointing out their mutual independence by his carefully controlled isolations and pure cultures. From a practical point of view this distinction has also a certain amount of interest, inasmuch as it is evident that *C. Piceæ* as a blueing fungus is of subordinate imporf tance. MÜNCH (work cited, p. 547) describes it as the commonest of those fungi which appear on the sapwood of the spruce and the silver fir, but he does not seem to be quite sure as to what part it plays. On the one hand it was proved that the attacked wood assumed normal blueing, on the other, it happened that only a faint discoloration could be observed, or the wood was entirely unchanged. When MÜNCH found that

some of his pure cultures on gelatine assumed a reddish-brown tint, others turned greenish-brown, and others again were quite colourless, he suggested as a possible explanation of this that the species, maybe, contained several varieties, characterized by different coloured mycelium, and he seems also to be trying to find in this an explanation of the very versatile faculty of the fungus to develop blueing. His observation, quoted in another connection, to the effect that the nature of the carbon-source exercised an influence upon the colour of the mycelium seems to have a greater bearing on this problem. As at any rate *C. Piceæ* on spruce and silver fir predominates over those fungi which always cause blueing, this might possibly account for these kinds of timber being less frequently damaged than, for example, pine.

From England there are also available some interesting observations concerning the occurrence and importance of *C. Piceæ*. According to MAC CALLUM (work cited, p. 233) this fungus is very common there and occurs on pine wood always intermixed with other species, whilst on spruce it develops practically in the same way as in »pure culture». In the latter case, however, the wood remains unstained, even when perithecia have developed to such an extent that they completely cover the surface. In pure culture on pine-wood the fungus causes only a very faint discoloration, and when found on blued timber, other species of fungi are invariably present.

In view of the above observations we may say that FALCK (1916, p. 141) was unfortunate when in his treatise on the blueing of timber in TROSCHL's »Handbuch der Holzkonservierung», he selected as an example a fungus which he considers to belong to *Ceratostomella Piceæ* Münch, or at last to be closely related to the same. There is very little doubt that he actually investigated the different stages of development of the supposed species, but at the same time it appears as if he also treats and illustrates mycelia with reproductive stages, which have no connection with *C. Piceæ* (cf. p. 253).

We shall now proceed to relate our own observations concerning *C. Piceæ*. On malt-agar it develops a compact, light-grey air-mycelium. The under-side of the colonies finally turns dark olive-green, and the smell reminds one of »high» cheese. The rate of growth is 3 (cf. note p. 164) i. e. about the same that characterizes *C. cærulea*. In due time coremial strands appear in the air-mycelium, but prior to that the graphia characteristic for the species, which is considered identical with CORDA's *Graphium penicillioides*, have already developed. The first are occasionally deposited in concentric belts (fig. 9); similar observations have been made by Miss RUMBOLD (1911, p. 454) in a culture of a gra-

phium from *Liquidambar styraciflua*. In cultures from older myceliar strains the formation of graphia is, however, less regular. The perithecia are sometimes entirely absent. Both MÜNCH and MAC CALLUM have previously had similar experiences. In our experiments they have developed only on a very acid substratum (0,05 % of lactic acid).

On timber the fungus forms a fairly compact, light-grey air-mycelium, from which graphia are soon thrown out in profusion. On the other hand, the perithecia had not fully ripened even after a period of three months, but earlier stages of development of such — also with necks — could be observed on the surface of the timber. The superficial growth of the mycelium is identical on pine and spruce-timber.

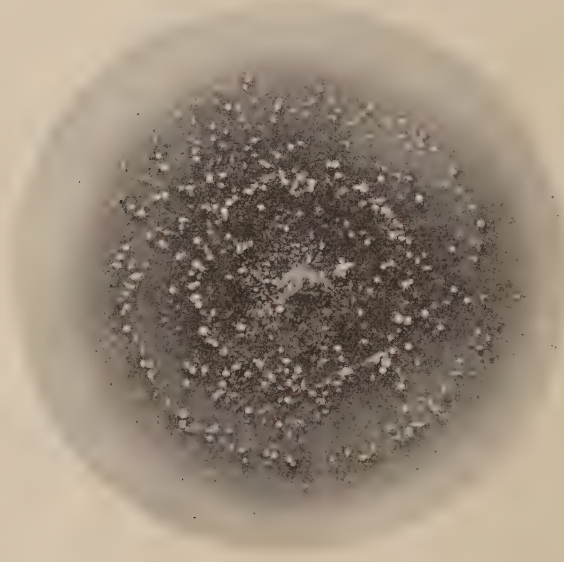


Photo by E. Melin.

Fig. 9. *Ceratostomella Piceæ*. Graphia in concentric belts (× 1,3). Pure culture on malt-agar.
Grafier i koncentriska bälten (× 1,3). Renkultur på maltagar.

The above-mentioned data show that certain biological differences exist between *Ceratostomella Piceæ* and *C. cærulea*. We also find great morphological differences. The very shape of the perithecia is different. The ventral part of the perithecia in *C. Piceæ* is spherical, and not flattened; out of the 10 perithecia measured only one was observed with a height slightly less than the width at the equator. The measurements vary between 192 and 224 μ. Outwardly the ventral part is covered with closely growing, fairly straight and distended hairs. The length of the neck varies considerably, between 1,06 and 1,97 mm., the average being about 1,5 mm. The thickness at the base is about 32 μ and under the ciliary fringe 14—16 μ. Abnormally shaped perithecia are not uncommon. Those with several necks occur comparatively often (cf. fig. 10 *a*) and occasionally also those with wholly or partially malformed, very thick necks.

The cilia afford the safest characteristic for distinguishing between the perithecia of *C. cærulea* and *C. Piceæ*. In the latter species these

are much shorter, indeed, so much so that the longest observed in *C. Piceæ* do not even approach the shortest in *C. cærulea*. The variation lies between 10,7 and 21,4 μ. The cilia in the same fringe are also some-

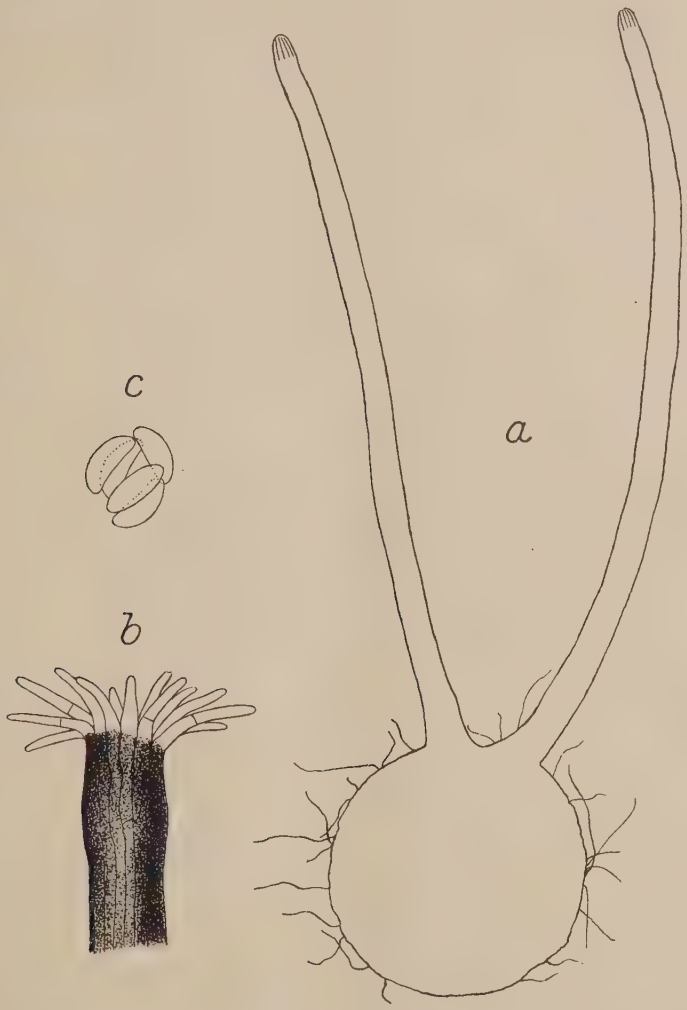


Fig. 10. *Ceratostomella Piceæ*. *a*. Perithecium with 2 necks (× 140). *b*. Fringe of cilia (× 630). *c*. Spores (× 2175).
a. Perithecium med 2 halsar (× 140). *b*. Cilliekrans (× 630). *c*. Sporer (× 2175).

what different in length, but vary very little on the whole. Their thickness also shows different figures. At the base they come up to 3,2 μ and under the rounded top 2,4 μ, their absolute width being thus

greater in the *C. Piceæ*, and this impression is strengthened by their short length. It should be added that it is fairly easy to observe the transversal walls of these cilia, and it has been found that as a rule there is only one in each; consequently they are formed of 2 cells (fig. 10 *b*). It is quite possible that the number of cilia may be somewhat lower than in *C. cærulea;* but our investigations into this detail are not sufficiently thorough for enabling us to express a definite opinion. The results of our counts vary between 16 and 24, the average being probably about 20.

The spores (fig. 10 *c*) are of the same magnitude as in *C. cærulea* according to our measurements 2,3—4,6 × 1,6 μ. On ripening they are embedded in masses of fatty oil which quite fills the ventral part of the perithecia.

The conidial formation occurring direct on the air-mycelium is remarkably luxuriant. The commonest type of conidial formation is similar to *Cephalosporium;* the conidia grow in head-shaped agglomerations on generally rather short, upright hyphal branches (fig. 11 *a*). The ear-shaped form which is so common in *C. cærulea* seems to be absent in *C. Piceæ*. MÜNCH mentions nothing about this, and for our own part we have only on a single occassion seen a trace of the ear-shaped formation of a conidial agglomeration. On the orther hand, conidial formation does not infrequently occur direct from the substratum hyphæ (fig. 11 *b*), but it is more sparse and irregular Moreover, in agar-cultures it is customary for the conidial formations to be entirely submerged, a fact which MÜNCH (1907, p. 553) has also observed. It is quite natural that in such cases their type changes and becomes less uniform. The myceliar conidia are larger than those developed on the graphia, at any rate as a rule, but they vary considerably in size. Our measurements have given the following results: length 8—12,8 μ, thickness 3,2—4 μ. The latter measurement is not always reduced in proportion to the length, consequently one also comes across a number of broader forms of conidia (fig. 11 *d*)

We have no reason to enter into further detail here concerning the development of the graphia, inasmuch as MÜNCH (1907, p. 547 et seq.) has already rendered a detailed account of the same subject. They often appear on wood as ostensibly quite independent formations, when the superficial mycelium is so scarce as to be quite inconspicuous. On malt-agar they also often develop from the very thin and sparse net of hyphæ (fig. 12 *a*) which from the edge of the substratum spreads itself over the glass wall. The most luxuriant formation of graphia is, however, produced on the nutritive substratum. As it concentrates itself on the

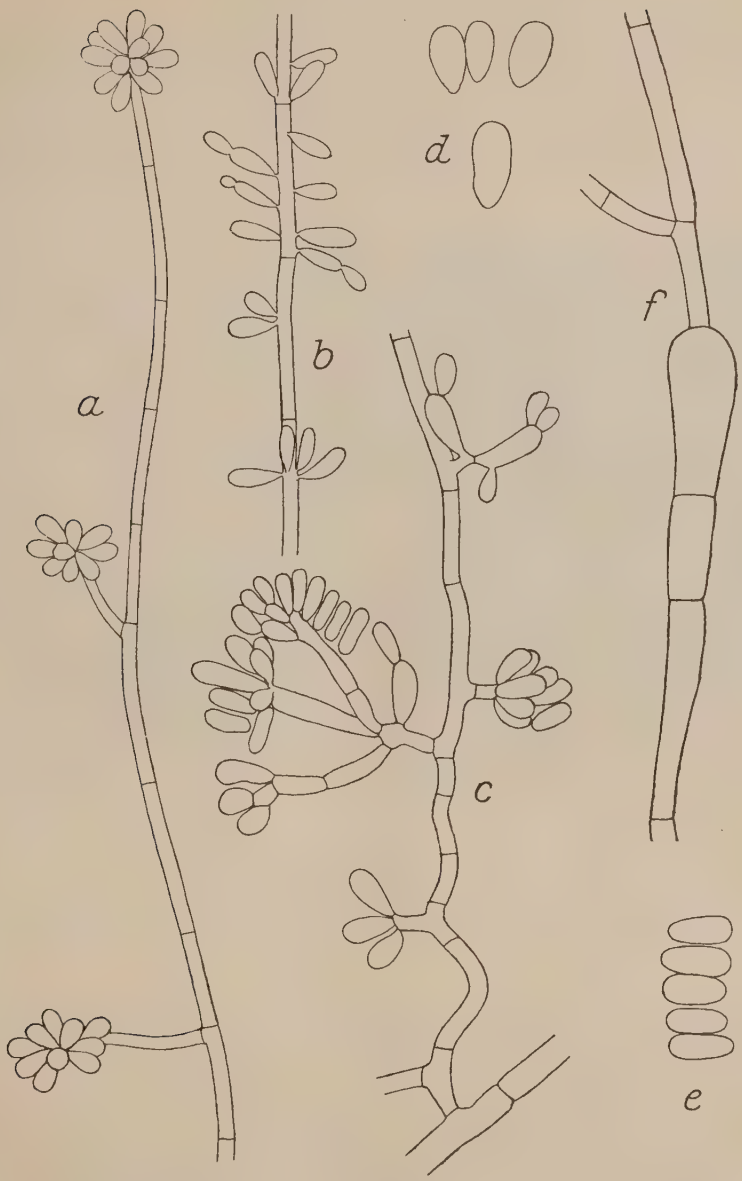
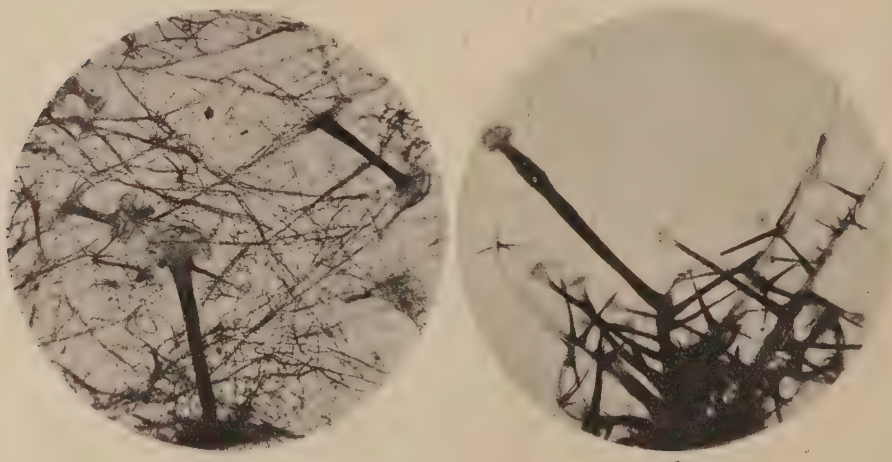


Fig. 11. *Ceratostomella Piceæ*. *a*. Hypha with conidial formation of *Cephalosporium*-type (× 1125). *b*. Conidial formation direct upon substratum-hypha (× 1200) *c*. Conidial formation on a submerged hypha (× 1125). *d*. Conidia from the air-mycelium (× 2175). *e*. Graphium conidia (× 2175). *f*. Hypha with clavate row of cells (× 1125). Pure culture on malt-agar.

a. Hyf med konidiebildning av *Cephalosporium*-typ (× 1125). *b*. Konidiebildning direkt på en substrathyf (× 1200). *c*. Konidiebildning på en submers hyf (× 1125). *d*. Konidier från luftmycelet (× 2175). *e*. Grafiumkonidier (× 2175). *f*. Hyf med klubblikt ansvälld cellräcka (× 1125) Renkultur på maltagar.

whip-lash shaped, more or less ramified coremia, rather complicated graphia formations are developed in due time (fig. 12 *b*), in which also conidial clusters of the *Cephalosporium*-type occur everywhere. The graphia have a fine, straight, black stem, up to 2 mm long consisting of glutinated, parallel hyphæ. Towards the top it widens into a thick brush, more or less widened at the sides, which can even assume the form of a hemisphere (with the flattened side downwards). It consists of fine,



a *b*

Photo by T. Lagerberg.

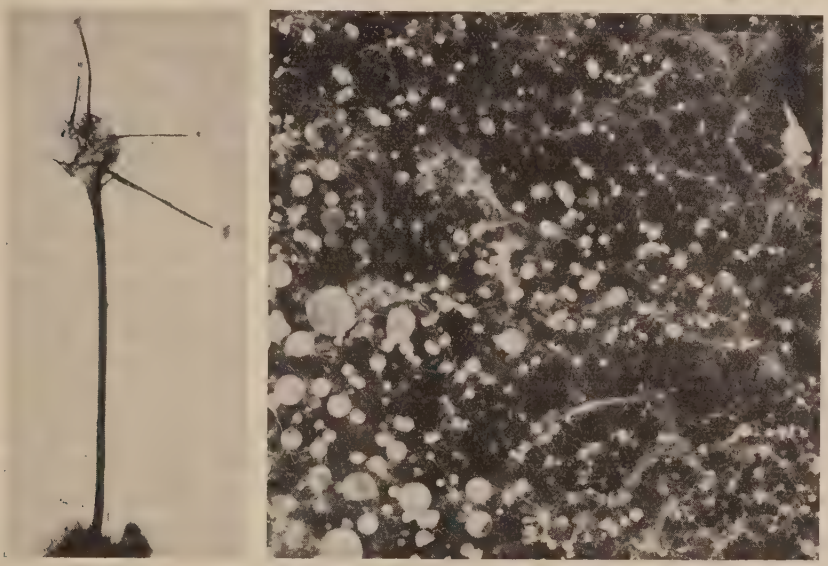
Fig. 12. *Ceratostomella Piceæ*. *a*. Graphia, developed from a sparse net of hyphæ, grown direct on the glass-wall in a test-tube culture, photographed in water under cover-glass (× 40). *b*. Formation of graphia from threads in the air-mycelium (× 22). Pure culture on malt-agar.

a. Grafier, utvecklade från ett glest hyfnät, som vuxit direkt på glasväggen i en rörkultur, fotograferade i vatten under täckglas (× 40). *b*. Grafiebildning från strängar i luftmycelet (× 22). Renkultur på maltagar.

greatly ramified, hyaline hyphæ, from whose apices conidia are budded. At the same time they give also off some water which in the air saturated with moisture remains on the apex of the graphium as a clear drop. Seen from above it looks, however, like a milk-white globe as the result of the masses of conidia which are suspended in the liquid, and which on account of their weight are immediately dicharged on the head of the graphium. Sometimes these watery globes from adjoining or neighbouring graphia unite into quite large sized ones (cf. fig. 13 *b*). The conidia are considerably smaller than the mycelium conidia and mutually more equal in size. The length varies between 3,2 and 4,8 μ, and the breadth between 1,6 and 1,9 μ. The basal termination is somewhat narrower than the top, but both are decidedly roundly-obtuse (fig. 11 *e*).

Even the graphium conidia reproduce themselves by budding, which condition undoubtedly contributes very much to the growth of the conidial mass in the drop of water.

In nature one encounters for valid reasons less frequently graphia supporting drops of water. As a rule, the conidia form a sticky ball, which in dry weather hardens and sometimes assumes the colour of



a *b* Photo T. Lagerberg.

Fig. 13. *Ceratostomella Piceæ*. *a*. »Proliferous» graphium — cf. p. 182 — (× 28). *b*. Graphia with terminal water bulbs (× 6). Pure culture on malt-agar.
a. »Prolifererande» grafium — jfr sid. 182 — (× 28). *b*. Grafier med terminala vattenkulor (× 6). Renkultur på maltagar.

honey. It is quite natural that under such circumstances they cannot easily be scattered by the wind. Dissemination is probably epizootic, or else occurs through precipitation within short distances.

In cultures ramified graphia are by no means rare. It should be observed that in such cases where proper ramification occurs, the branches diverge at a very sharp angle. There is namely another possibility for the occurrence of composite graphia, which has also been interpreted as a ramification but is in reality something totally different. In older cultures lavishly branched graphia often appear, and, strange to say, they grow almost at right angles to the mother axis. MÜNCH (1907, p. 550, fig. 8) mentions and illustrates a case in point, and MAC CALLUM (work cited, p. 234) has observed that small graphia in more

advanced cultures grow readily from the head of the original ones. The same phenomenon is finally also mentioned by Miss RUMBOLD (1911, Pl. 2, fig. 11) with regard to a graphium from the wood of *Liquidambar styraciflua*. It is, however, practically certain that no ramification exists in the cases referred to. In *Ceratostomella Piceæ*, at least, the new graphia develop from a mycelium which has developed secondarily on the old graphium, probably from its own conidia. From fig. 13 *a* we see thus that a loose net of hyphæ has evidently developed on the surface of drop of water which at one time was supported by the main graphium, and from this foundation new, small graphia have developed in different directions; at a hasty glance we can conceive — according to MÜNCH's opinion — that actual »proliferation» exists here. Such an explanation seemed more likely when the young graphia are growing directly upon the main stem. The unusually large angle at which this ramification is carried out must, however, seem strange. A closer examination under the microscope has in many cases enabled us to make sure that the supposed branches are independent epiphytes which live on the mother without being genetically connected with her.

If we study the direction of growth of the graphia we come to the conclusion that it is not so much determined by the geotropic irritability but in the first instance by the position of the substratum's surface, for it has been discovered that as a rule the graphia grow at right angles to the latter. In a tube-culture the graphia which emanate from the side of the tube lie horizontally, and they do not bends in order to bring the upper part into a vertical position. This being the case the above-mentioned orientation of the epiphytic graphia becomes comprehensible.

Actual miniature graphia of a very simplified type also occur in *Ceratostomella Piceæ*. They have already been dealt with by MÜNCH (1907, p. 549, fig. 7). In our cultures of a somewhat more advanced age these types have developed very profusely; they may in all probability be regarded as hunger-forms. The size varies considerably, but they are all characterized by one common feature, viz: that the stem is not very pronounced against the conidiferous upper part but exhibits right from the bottom an evenly increasing thickness. In the simplest cases the graphium issues only from a single hypha and its lowest part then also consists of only a simple hyphal cell. It may here be added that the last-mentioned, rudimentary type of graphium somewhat resembles *Leptographium Lundbergii*, dealt with later on, which, however, is an entirely independent species, although hitherto neglected.

Ceratostomella Piceæ grows in wood in approximately the same way as *C. cærulea.* The principal difference lies in the aforesaid, weak capacity of blueing the wood. In one of our inoculation experiments a piece of pine-wood after a period af three weeks showed a discoloration distinctly discernible by the naked eye, which, however, was confined to the three outermost rings. Within this portion the parenchyma of the pith-rays was replete with slender, brown hyphæ, whose walls here and there were covered with a brown exudation. Further in the wood the hyphæ grew extremely narrow and almost colourless. The shape of the parenchyma cells had not undergone any very great change; only in the autumn-wood the beginning of a constriction resembling an hour-glass could be observed. The direct perforation of the tracheid walls was an extremely common occurrence. Perfectly straight hyphæ have been observed, which in the course of their progress had pierced 8 walls in succession, but no adpressoria of any strength are developed. Further in the wholly uncoloured wood the thickwalled tension-wood tracheids were perforated by hyphæ which were only 1,8 μ broad; the passage through the wall had a width of 0,4 μ.

In another inoculation experiment very distinct, though not very intense, blueing was obtained on pine-timber (Plate I). A number of pith-rays appeared on the radial section to the naked eye as dark lines. Their parenchyma cells were filled with slender, light olive-green, but thin-walled hyphæ. Such hyphæ occurred also very profusely in the tracheids, although they were colourless, and only 1,1—1,5 μ thick. The peculiar, elongated, clavate form of some hyphal cells, which also occurs in *C. cærulea*, was very common in the case in question (fig. 11 *f*). The swelling always occurred at the upper end of the cell and attained up to 4 μ, whilst the hind-part was only 1,5 μ thick. Simultaneously with the last-mentioned experiments a second test was made on the same piece of pine-timber with another strain of *C. Piceæ*. Although a vigorous surface mycelium and graphia in profusion were developed in this case, too, no blueing whatever occurred. The strain used in the latter test had been kept in pure culture for nineteen months; that used in the former, on the other hand, only for four and a half. This is probably the reason why the development of the two stocks was different in both tests. It is quite evident that the fungus gradually weakens in cultures on an artificial substratum; which inter alia also finds expression in the fact that the formation of graphia grows less regular or disappears entirely on malt-agar.

In inoculation tests on spruce-wood as a rule no blueing occurred. For instance, no discoloration had resulted from the two last-mentioned

strains in tests carried out simultaneously with the aforesaid pine tests (Plate I).[1] Under the microscope it could, however, be proved that the entire sapwood became interwoven with fine and practically colourless hyphæ after a period of three weeks. It was only in the resin-ducts, where they were better developed, that a brownish tint could be observed on their walls. Direct perforations were extremely common, and clavate cells appeared here and there, even on hyphae which had grown through the parenchyma cells of the pith-rays.

Ceratostomella pluriannulata HEDGCOCK.

Hitherto this species has been found on a single occasion.

1. Värmland, Ransäter. Stored spruce-timber, 11. 9. 1925. Material obtained from Mr S. JOHANSSON.

The similarity between this Värmland form of *Ceratostomella* and the North American *pluriannulata* described by HEDGCOCK is so great that there can hardly be any doubt as to their being identical. MÜNCH (1907, p. 564) has certainly expressed the opinion that the latter is an abnormally developed *C. cærulea*, but the results of our observations have led us to believe that not only morphological but also biological differences occur which positively contradict their being identical.

HEDGCOCK obtained his fungus from a piece of blued sapwood of *Quercus rubra*. He afterwards transferred it to pine-wood and found that the mycelium very easily also penetrated this wood. It is not clear from his account, however, whether the fungus causes any very intense blueing; as far as we have experienced this is probably not the case.

On malt-agar the fungus develops a compact, snowy-white air-mycelium, and this colour is preserved also in older cultures, at least in their upper portions (fig. 14). In this respect there exists a decided difference as compared with *C. cærulea*. The colonies turn dark olive-green on the under-side; they do not give off any definable smell. The vegetative development progresses slowly — the rate of growth (cf. note p. 164) is only 2 — but fertility is all the swifter. The immediate development of the perithecia is a peculiarity of this species. In cultures from freshly isolated strains they are frequently fully developed in five days with spore spheres on the opened necks. HEDGCOCK (p. 73) has made exactly the same observation. In cultures from older stocks, on the other hand, the perithecia make their appearance much later, and likewise when the fungus is being reared on wood. In the latter case,

[1] In an earlier experiment with spruce-timber faint blueing in the outer rings was obtained by *Ceratostomella Piceæ* (cf. Table 6).

quite a number of perithecia could, however, be found after a month. Both on pine and spruce-wood the fungus forms a compact, snowy-white air-mycelium of about the same intensity.

The perithecia attract interest in several respects. The ventral portion, which is often thickly covered with hairs even in the earliest stages (fig. 16 *a*) appears as a rule to be spherical, but varies considerably in size — between 112 and 224 μ in diameter — sometimes it is distinctly pear-shaped, with a greater height than breadth, e. g. 144 and 128 μ respectively. The principal characteristics of this species are to be found in the necks. Thus in a large number of the perithecia a further fringe or fringes of cilia (fig. 15) are developed under the terminal one. These accessory fringes are generally more or less incomplete, and sometimes they are only indicated by one or a few cilia. A definite, more particularly investigated case which affords an interesting illustration of this detail must be cited here. The perithecium in question had a spherical ventral portion measuring about 160 μ, and its neck attained the extraordinary length of 4,8 mm. At 3 730 μ above the ventral part there occurred the first complete fringe of cilia, and 200 μ above this followed a second; 114 μ higher up a third appeared; and 39 μ above the latter a fourth. The fifth fringe which was at the same time the terminal one was 57 μ above the fourth. Such complicated cases as the one just dealt with are certainly not common; one or two accessory fringes appears to be the normal number. In order to understand their origin the following case will serve as an explanation. A formation of cilia of rather restricted extent occurred on the perithecium in question. The neck was 3 040 μ long and had

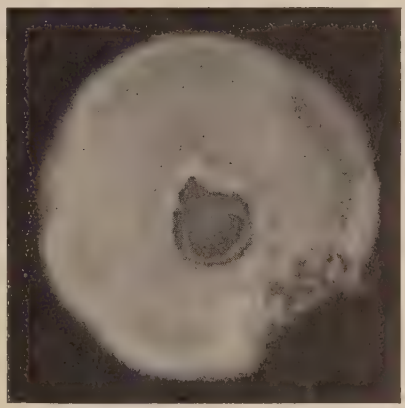


Photo by E. Melin.

Fig. 14. *Ceratostomella pluriannulata.* Pure culture on malt-agar (× 1,4). Renkultur på maltagar (× 1,4).

128 μ	below	the	terminal	fringe	of	cilia	1	cilia
160 μ	»	»	»	»	»	»	1	»
208 μ	»	»	»	»	»	»	1	»
272 μ	»	»	»	»	»	»	4	» in a cluster
320 μ	»	»	»	»	»	»	1	»
400 μ	»	»	»	»	»	»	2	»

Fig. 15. *Ceratostomella pluriannulata.* The upper part of a perithecium-neck with 2 fringes of cilia (× 250).
Övre delen av en peritheciehals med 2 ciliekransar (× 250).

MÜNCH (1907, p. 564) seems to be inclined to connect these surplus cilia with a repeated penetration of the apex of the neck. But as the cilia form the terminal pieces of the cervical hyphæ, it is difficult to imagine that the tip should be able to continue growing after it had once opened. In our opinion the surplus of cilia fringes occur independent of the longitudinal growth of the neck, and their cilia must be looked upon as lateral formations of the neck-hyphæ, and not as terminal points of the same. This interpretation fits best cases like the one just mentioned, and is probably also the right one.

The number of cilia in the terminal fringes is subject to great variations in perithecia of the same magnitude; the lowest observed being 21 and the highest 58. The cilia within the same fringe are, however, of fairly uniform length and measure from 39,3 to 67,8 μ. The form of the cilia is an important characteristic of the species, for it is indicated by a manifest angustation towards the apex — from a transversal measurement of 3,2 μ at the base to only 0,8 μ below the top (fig. 16 *b*). This tapering is also mentioned by HEDGCOCK (work cited, p. 74). The length of the neck in *C. pluriannulata* varies more than that in any other species we have examined. According to HEDGCOCK the average length is 1,5 mm., which almost coincides with what we have found. In single instances, however, the neck as appears from our aforesaid figures may attain a length of 5 mm.; in perithecia with the same ventral measure one also finds necks of very

different lengths, e. g. 560 and 1,200 μ. Below the top the average thickness is 16 μ.

Apart from normal perithecia, the fungus develops dwarfed ones in agar-cultures. Their ventral part is often slightly pear-shaped — according

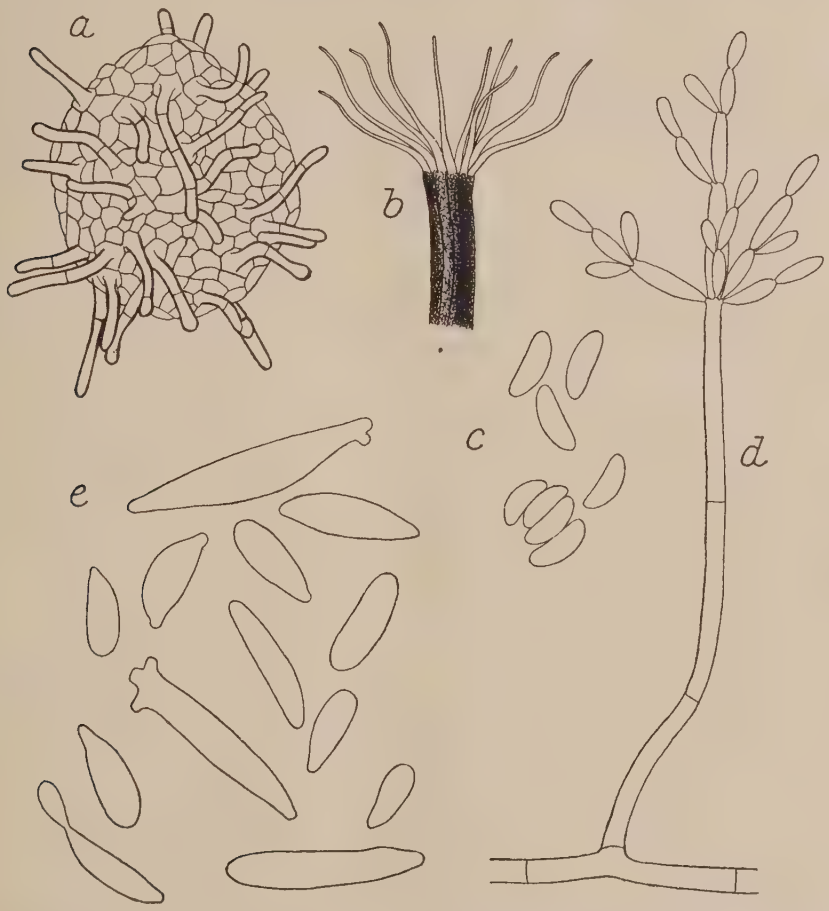


Fig. 16. *Ceratostomella pluriannulata*. *a*. Young perithecium with projecting hairs (× 630). *b*. Fringe of cilia (× 630). *c*. Spores (× 2175). *d*. Conidial cluster of *Cladosporium*-type (× 1125). *e*. Conidia (× 2175). Pure culture on malt-agar.

a. Perithecieanlag med utväxande bukhår (× 630). *b*. Ciliekrans (× 630). *c*. Sporer (× 2175). *d*. Konidieställning av *Cladosporium*-typ (× 1125). *e*. Konidier (× 2175). Renkultur på maltagar.

to a measurement 57,0 × 60,7 μ — and the neck attains about ten times the length of the former. The number of cilia drops in such cases to about 10—13. The fruit-bodies of these small dimensions possess, however, an absolutely regular spore-formation. They are probably the

outcome of the peculiar conditions offered by an agar-culture; they have not been observed on wood.

HEDGCOCK states that the spores are kidney-shaped and $4—5 \times 1,5—1,7$ μ in size. According to our own observations they are shaped like the section of an orange, with a slightly concave front edge; the dimensions practically correspond to those quoted above and have been found to be $4,0—4,4 \times 1,5$ μ (fig. 16 *c*).

The snowy-white colour which is characteristic of the air-mycelium in *C. pluriannulata* is largely due to the extremely luxuriant conidial formation. The latter appears to proceed under slightly varying forms. Short upright branches of hyphæ are terminated by fringewise arranged rows of cells, themselves often branching out once or twice, and usually developed on several levels one above the other. In other words, it is the *Cladosporium*-type characteristic of other species of the genus that we meet again here; fig. 16 *d* depicts such a conidial cluster of a less complicated kind. On coming into contact with water it falls to pieces altogether, in consequence of which the form and size of the conidia vary very considerably (fig. 16 *e*). As will be seen, distinctly spindle-shaped shoots appear sometimes on the original branch-cells, from which branches have previously grown. The terminal cells, which are more or less pear-shaped, are said by HEDGCOCK to be on an average 6 μ long and 1,5 μ broad; according to our measurements the corresponding figures have been 5—6,6 and 1,8—2,3 μ respectively.

Transplanted to pure culture on pine-wood *Ceratostomella pluriannulata* proves to possess only a comparatively slight faculty for blueing. After three weeks' growth the mycelium produced a grey, rather streaky discoloration (Plate I), which did not extend to the whole of the sapwood. The hyphæ which occur here are thin-walled and appear under the microscope to be almost hyaline; their thickness varies between 3 and 7 μ. The cells quite often assume the elongated clavate form which has been described in connection with the two previous species. The hyphæ grow profusely, straight and only sligthly ramified in the lumen of the tracheids, and perforations of the tangential walls are a common occurrence. Visible swellings at the points of contact beyond the normal width of the hyphæ are absent, and the perforation is extremely fine. The parenchyma cells of the pith-rays are seen here and there contracted like an hour-glass. They are replete with straight, narrow and sligthly ramified hyphæ, which chiefly in the broader pith-rays are densily packed. Their cells contain masses of strongly refractive drops of fat, but as the membrane is thin and not very pronounced it looks as if the parenchyma cells themselves might contain

a coherent granular substance. The cells in the parenchyma sheath of the vertical resin-ducts are filled in a similar manner, as are also some of the spring-wood tracheids in proximity to the marginal rows of cells of the pith-rays.

After three weeks' growth the fungus did not cause any discoloration visible to the naked eye (Plate I) on spruce. The mycelium had, however, penetrated about 15 mm below the tangential surface of the inoculated sector. The hyphæ occurred sparsely in the parenchyma cells, and were extremely fine and colourless. Perforations in the tracheid walls could be observed everywhere but they were remarkably fine.

Ceratostomella Pini MÜNCH.

This species has been taken in pure culture from the following districts:

1. Västmanland, Bjurfors, 4. 8. 1925. On sawn pine-timber in the timber-yard from blueing at contact with stickers.
2. Västmanland, Bjurfors' State Forest, 8. 8. 1925. From 2 partly-peeled pine-trunks which have been felled and lying in the forest for a year.
3. Uppland, Stocksund, Mörby, 28. 9. 1925. From pine-timber, felled in the spring of the same year and stored under cover during the summer.

Our joint observations of this fungus in nature justify the assertion that in Sweden *Ceratostomella Pini* is particularly common on pine, and as it is also a very active form it belongs undoubtedly to our most important blueing fungi.

MÜNCH (1907, p. 541) has given an exhaustive description of this species, and our own observations practically completely confirm the statements he has made. The fungus grows in a very characteristic manner in the crack-shaped cavities which are caused on the pine logs when the bark loosens. Both on the exposed surface of the wood and on the inside of the thick bark it develops freely as a thin, sooty coating. This consists chiefly of small sclerotic pillars — composed of short, brownwalled cells, but otherwise greatly varying as to form and size. MÜNCH (1907, p. 543) has discovered that these formations are established on the very layer of cambium like pseudoparenchymatous collection of hyphæ. They grow in height — when fully grown they are about 0,5 mm. in length — thereby breaking the cambial tissues and raising the bark covering so much that the fungus gets sufficient space to develop its reproductive organs below the same. Soon masses of extremely small, lustrously black perithecia (fig. 17) appear among the sclerotia. Bursting can also take place through the development of

the sclerotia in the inner part of the secondary phloem, which through the periclinal arrangement of its various cellular elements is particularly liable to break up into concentric layers. The sclerotia have therefore a very important task in the history of development of the fungus; they are, however, not unique of their kind. Similar formations with the same function, although more active, occur also in another species of the *Pyrenomycetes*, viz: *Eutypa hydnoidea* von Höhnel, which in Sweden is widely disseminated as a dangerous parasite on birch trees. Its stroma-stage, known under the name of *Radulum aterrimum* Fries, consists chiefly of closely-placed, pillar-shaped excrescences whose task it is to raise and finally burst asunder the bark which covers the branches and parts of the trunk encroached upon by the fungus.

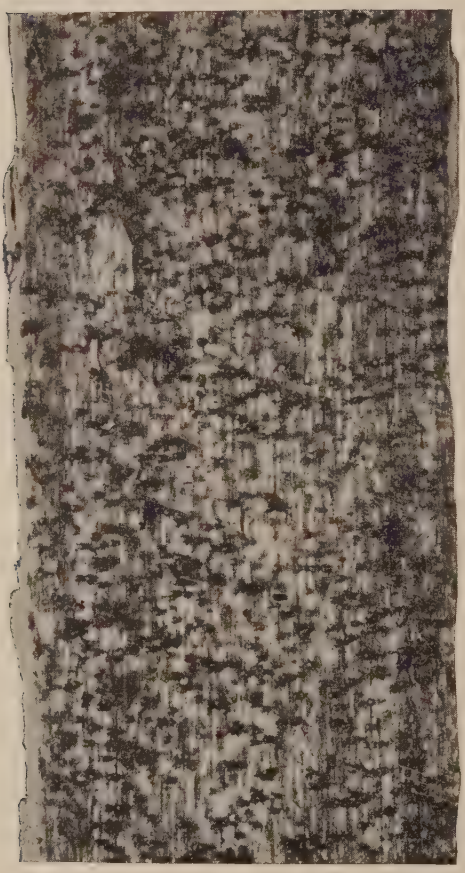


Photo by T. Lagerberg.

Fig. 17. *Ceratostomella Pini*. Perithecia and sclerotia on the wood-surface of a blued pine-log (× 12).

Perithecier och sklerotier på vedytan av en blånad tallstock (× 12).

Ceratostomella Pini behaves in culture somewhat differently from the previously treated species of this genus. On malt-agar, for instance, no air-mycelium proper is developed, but the hyphæ grow direct on the surface of the substratum or also submersed in it. Its rate of growth is 5,5 (cf. note p. 164).

The hyphæ soon turn dark so that the under-side of the colonies assumes a brownish tint. No specific smell is developed. In older cultures intensive budding of the conidia occurs, and the colonies obtain by this means a sticky, porridge-like consistency on the surface (fig. 18). Numerous perithecia are concealed in this mass, and in addition there are also often dark sclerotial bodies of irregular shape.

In pure culture on wood *Ceratostomella Pini* grows with a compact,

greyish air-mycelium, slightly more vigorous on pine than on spruce, and through the same the discoloured surface of the wood appears in a bluish-grey tint. After a month's development at living-room temperature, the fungus had formed numerous young perithecia. MÜNCH asserts that he has observed such already after four days, but states at the same time that a few weeks are necessary for them to attain full ripeness.

Photo by E. Melin.

Fig. 18. *Ceratostomella Pini.* Pure culture on malt-agar, slightly reduced.
Renkultur på maltagar, obetydligt förminskad.

C. Pini is properly characterized by the minuteness of its perithecia. Under a magnifying glass they look like tiny spheres, and measurements have also proved that their ventral parts are quite globular. But the variation in size is considerable. The smallest diameter observed was only 67,7 μ and the largest 150 μ. It also looks as if larger fruit-bodies developed in agar-cultures than on wood; in the former an average diameter of 115 μ has been found, whilst in the latter it

reached only 80 μ. In his description of the species MÜNCH (1907, p. 541) states that the ventral part is not pilose. We have, however, never met with any entirely bald perithecia, even if the ventral hairs are not equally pronounced as in the larger species of the genus. Our observations also differ sligthly from those related by MÜNCH with regard to the length of the neck. He states that the neck is of the same length as the diameter of the perithecium. We have, however,

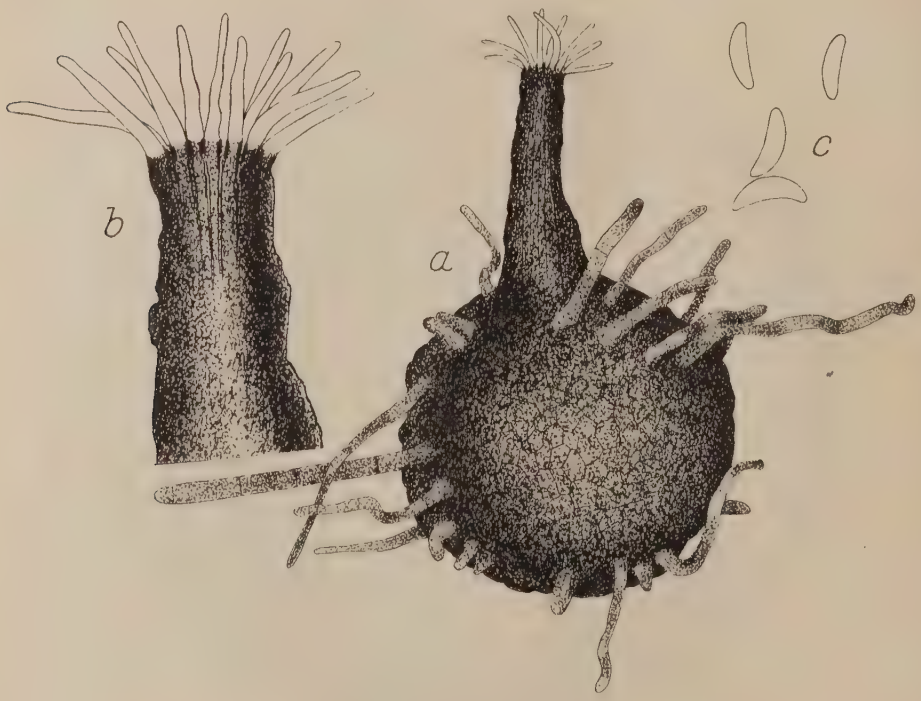


Fig. 19. *Ceratostomella Pini*. *a*. Ripe perithecium (× 630). *b*. Fringe of cilia (× 1200). *c*. Spores (× 2175).
a. Moget perithecium (× 630). *b*. Ciliekrans (× 1200). *c*. Sporer (2175).

found that the latter measurement as a rule clearly exceeds the length of the neck (cf. fig. 19 *a*). The comparatively very short, and simultaneously slightly curved, neck is a good characteristic. The size of the neck at the base is about 32 μ, but under the top it has dropped to about 11 μ.

The terminal fringe contains on an average only 12 cilia measuring about 20 μ in length, which are of a remarkably uniform shape. Their thickness at the base is 1,6 μ; and at the apex 0,8 μ (fig. 19 *b*). MÜNCH states that the spores are somewhat larger (5 × 1,5 μ) than in the other spe-

cies, but the difference is nevertheless slight. Under the microscope they give the impression of being somewhat narrower and more curved. The length varies between 4 and 4,3 μ, and the breadth between 1 and 1,2 μ (fig. 19 *c*).

MÜNCH has quoted the head-like agglomeration on the apex of the short, upright hyphal branches as the almost universally prevailing type of

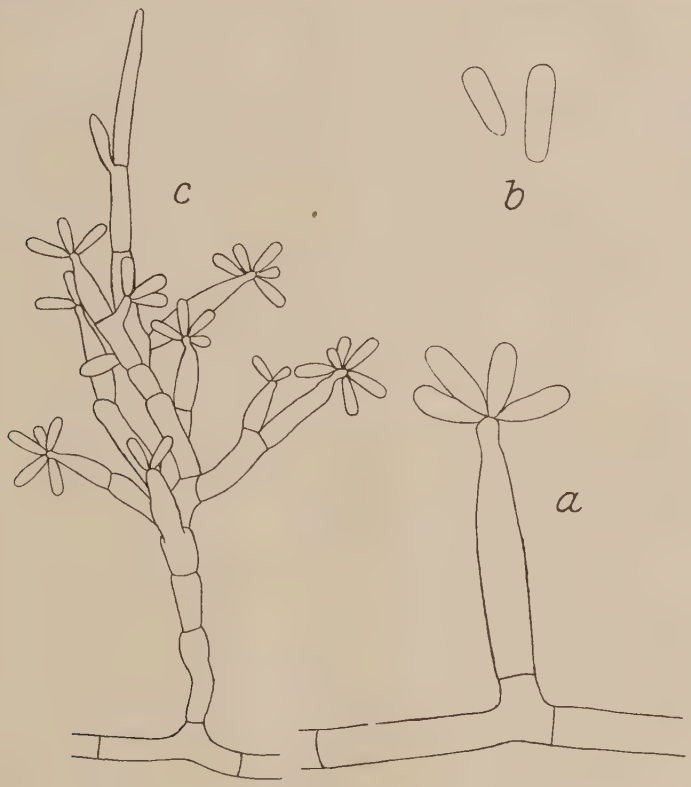


Fig. 20. *Ceratostomella Pini*. *a*. The simplest form of conidial formation (× 1175). *b*. Conidia (× 2175). *c*. Dendritic conidial cluster (× 1200). In *a* and *c* only a few of the conidia are remaining. Pure culture on malt-agar.

a. Den enklaste formen av konidiebildning (× 2175). *b*. Konidier. (× 2175). *c*. Dendritisk konidiesställning (× 1200). I *a* och *c* endast ett fåtal av konidierna kvarsittande. Renkultur på maltagar.

conidial clusters, and he considers it to be in complete accordance with the corresponding ones in *Ceratostomella Piceæ* and *C. cærulea*. According to our own observations a distinct difference appears, however, to exist in certain respects. Particularly striking is the very decided angustation towards the apex, which characterizes the conidia producing branches and the more or less spherical protuberance which occupies

the very apex and makes the conidia grow (fig. 20 *a*). Another difference is the shape of the conidia, which in this species is more elongated and of more even width (fig. 20 *b*). Especially in the isolated conidia the difference between apex and base is often scarcely perceptible, and the shape therefore becomes almost cylindrical. According to our measurements the size does not vary very much, viz. $5{,}6 \times 1{,}6\ \mu$ and $4{,}3 \times 1{,}5\ \mu$; the figures given by MÜNCH may be considered to correspond entirely.

With regard to the conidial development in *Ceratostomella Pini* the principal characteristic may, however, be the extremely complicated clusters which grow both on malt-agar and wood. They consist of racemose, dendritical systems of hyphæ on a main axis of fairly coarse and short cells. Their finest branches which may be of the fourth, or possibly even still higher order, are composed of such bodkin-shaped tapering cells which at quite an early stage grow direct from the substratum hyphæ and commence the conidial formation. The conidial cluster illustrated in fig. 20 *c* is one of the smaller ones; larger ones cannot be depicted with sufficient exactitude on account of the very close ramification. The picture is also incomplete, inasmuch as the majority of the conidia are broken off. According to MÜNCH as many as 50 may be found in one and the same agglomeration.

Ceratostomella Pini causes intense blueing in timber. The colour varies slightly. On a cross-section it can occasionally appear almost black-blue (Plate I); on a tangential section it looks dark leaden-grey if the wood has dried in living-room. The spreading of the blueing also proceeds rapidly. In pure culture on pine the whole of the sapwood can be entirely permeated and intensely discoloured after a period of growth of only 3 weeks. The parenchyma cells of the vertical resin-ducts and of the pith-rays are then replete with hyphæ, and the same also holds good for the cavities in the resin-ducts. Contractions in the shape of an hour-glass are common, especially in the autumn-wood of the rings. The pith-rays are discernible by the naked eye on radial sections, especially the larger ones, and the vertical resin-ducts appear as black lines drawn in Indian ink, and even strongly magnified the hyphæ have an almost black-brown colour. Their cells are generally long and narrow (3—4 μ thick), their course is somewhat sinuous; occasionally they are developed in convolutions which give an impression of pseudoparenchyma. The membrane is marked by irregular, dark laminations, between which the smooth surface displays an extremely fine granulation. The thickness of the hyphæ in the parenchyma of the resin-ducts rises to as much as 15 μ.

Before the content of the cells is consumed by the fungus it is subjected to fairly intense discoloration. The floccose remnants of plasma and the nuclei, which retain their shape unchanged for a long time, turn brown. It is also interesting to note that a brown stain quite generally appears in the walls of the parenchyma cells. This is especially distinct on the membranes of the large angular pits related to the tracheids and in the vertical parenchyma, where the walls can be perfectle dark, although the hyphæ themselves are almost hyaline. The pit-membranes of the tracheids also display a partial brown stain here and there, although the hyphæ here are rather scanty. *Ceratostomella Pini* has in all probability a capacity of giving off a dark colouring matter which is absorbed by the walls of the wood cells, for which reason the blueing in this case is not merely due to the innate colour of the hyphæ.

The hyphæ growing in the tracheids are very narrow, longicellular and have a finelygranulated membrane. Ramification is slight, but locally there occur lateral, dentritic systems of branches of short hyphæ bifurcated at the top. Sometimes the branches penetrate into the bordered pits, which may thus be more or less completely replete (fig. 21), otherwise the normal passage between the tracheids runs just through the bordered pits. The direct radial perforations which have been observed in *Ceratostomella cærulea*, *C. Piceæ* and *C. pluriannulata* are, as far as we have been able to discover, lacking in *C. Pini*. Some mural perforations of the type referred to, however, occur in the very instructive picture with which MÜNCH (1907, p. 542, fig. 24) has illustrated the development of the lastmentioned species.

For this reason we have very carefully investigated this detail, but have been unable to discover its occurrence on any material from our pure cultures on wood, even when the fungus had grown under optimal conditions.

Ceratostomella Pini develops remarkably strongly on sprucewood, although more feebly

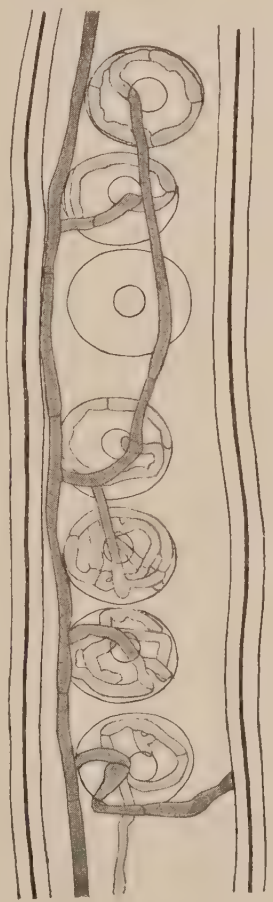


Fig. 21. *Ceratostomella Pini*. Pine tracheid with branches of hyphæ inclosed in the lenticular hollow of the pits (× 630).

Talltrakeid med hyfgrenar instängda i ringporernas linsformade hålighet (× 630).

than on pine (Plate I). The discoloration is then more greyish. The hyphæ concentrate here, too, upon the parenchyma, but their membranes are a fainter brown and have a scanty, granulated exudation. The hyphæ in the tracheids are very narrow, for long distances quite unramified and colourless. The fainter blueing thus fully coincides with the more scanty development of the hyphæ.

Endoconidiophora cœrulescens MÜNCH.

We have obtained this biologically very interesting fungus from the following localities:

1. Dalecarlia, Garpenberg State Forest, 4. 2. 1924. From 3 live spruce trunks into which the fungus had penetrated through blazed spots. Material supplied by Mr O. EKBOM.
2. Värmland, Ransäter, 11. 9. 1926. On stored spruce-timber (together with *Ceratostomella cœrulea*). Material supplied by Mr S. JOHANSSON.
3. Västmanland, Bjursfors State Forest, August 1926. On pine cordwood, felled in the winter of 1925/26.

Although we have not as yet definitely ascertained how far this fungus can be held responsible for blueing on coniferous timber, everything points to the fact that it is of great practical importance. It was discovered by us under circumstances under which it had previously not been observed in Germany, where it has originally been described by MÜNCH (1907, p. 536, 464). He does not however, mention whether in nature it prefers any certain kind of timber, but illustrates it growing on spruce. The fungus thrives remarkably in pure culture both on pine and spruce, but more intense blueing was obtained on pine. To judge from other experiences it may, however, be best to designate it as a spruce-fungus.

In the month of May 1922, some coniferous trees 80—120 years old were branded in the Garpenberg State Forest in Dalecarlia, the forest consisting chiefly of spruces. The branded trees were allowed to remain and were examined in Januari 1924. It was then discovered that »brand-blueing» had developed in a large number of the blazed trunks. *Endoconidiophora cœrulescens* grew pure from the material sent in. In order to give an idea of the extent to which this peculiar blueing had spread we render the following account.[1]

On the occasion of the aforesaid revision 260 spruce trees were selected for testing, and on these altogether 509 blazes had been made — the majority having as a matter of fact been blazed on two sides. 208 or 28 % of all the trunks were infected with blueing, and 374 or 73,9 %

[1] The information has been kindly supplied by Mr. O. EKBOM. He is rendering a detailed account of these blazing tests in another connection.

of the blazes had given access to the fungus. The infected timber had assumed an even, blue-grey tint. From the infected spot the blueing had spread in a longitudinal direction of the trunk (both upwards and downwards) and in a radial and periclinal direction. The radial advance is interrupted on the border-line of the heart, while the growth towards the sides continues. The cross-section of the blued timber assumes for this reason a characteristic crescent-shape close to the blaze. During the period of 20 months which had elapsed between blazing and the examination the fungus had managed to cause an astonishing amount of blueing. On 52 test trees blazed, which had an average diameter of 21,2 cm., the following average growth of blueing could be ascertained:

Longitudinal growth	174 cm.
Radial growth (close to the blaze)	3 »
Periclinal growth » » » »	6,7 »

A similar investigation on 10 test-trees, blazed only on one side, produced the following results as regards the development of the fungus:

Longitudinal growth	227 cm.
Radial »	3,2 »
Periclinal »	8,2 »

The most intense blueing from a blaze was measured on a trunk with 32 cm at breast-height. It had a length of no less than 3,8 m., a depth of 44 mm. and its greatest breadth was 57 mm. It may finally be pointed out that the blueing progressed more rapidly in broad-ringed trunks. It agrees in this respect fairly well with some kinds of rot, e. g. the top-rot and the brand-rot caused by *Stereum sanguinolentum*.

Maybe it should be added that we have naturally not been able to determine the nature of the blueing in every separate log of the material from which the above statements have been derived. There is nevertheless valid reason to believe that *Endoconidiophora cœrulescens* was solely responsible for the damage, as this not only in respect of the discoloration but also in regard to its general appearance was strikingly uniform.

Perhaps the best available characteristic by which this fungus can be determined is its smell, because it produces amyl-acetate in culture on the most varied carbon sources (maltose, glucose, dextrine, starch, oil) and apparently in large quantities, as the odour of this substance in a short time increases very intensely in a closed culture-vessel. The same odour is emitted by pieces of wood on which the fungus has grown more vigourously and it is also able to reveal its presence in nature by its smell.

The blued pine-timber from which we had isolated the fungus (see

places of discovery No. 3) had a distinct odour of amyl-acetate. Although we were unaware of the fact that *Endoconidiophora* also occurred upon pine we considered this fact to be already established on account of the unmistakable odour, and this assumption was subsequently verified, by the pure culture.

On malt agar the fungus develops at first a light-grey air-mycelium which gradually turns darker and darker and finally assumes a black-

Photo by E. Melin.

Fig 22. *Endoconidiophora cœrulescens.* Pure culture on malt-agar. Nat. size.
Renkultur på maltagar. Nat. storl.

brown colour. It possesses a distinctly radial, filamentary structure and develops so uniformly in all directions on agar-surfaces that the colonies for a long time retain a perfectly circular outline (fig. 22). The rate of growth is 10 (cf. note p. 164), a considerable value, which amongst other blueing fungi examined by us is only attained by a single one, viz. *Leptographium Lundbergii;* MÜNCH, too (1907, p. 569), emphasizing the remarkably rapid development of *Endoconidiophora,* states the radial growth to be fully 5 mm. per day at ordinary living-room temperature. The under-side of the colonies in the course of time turns

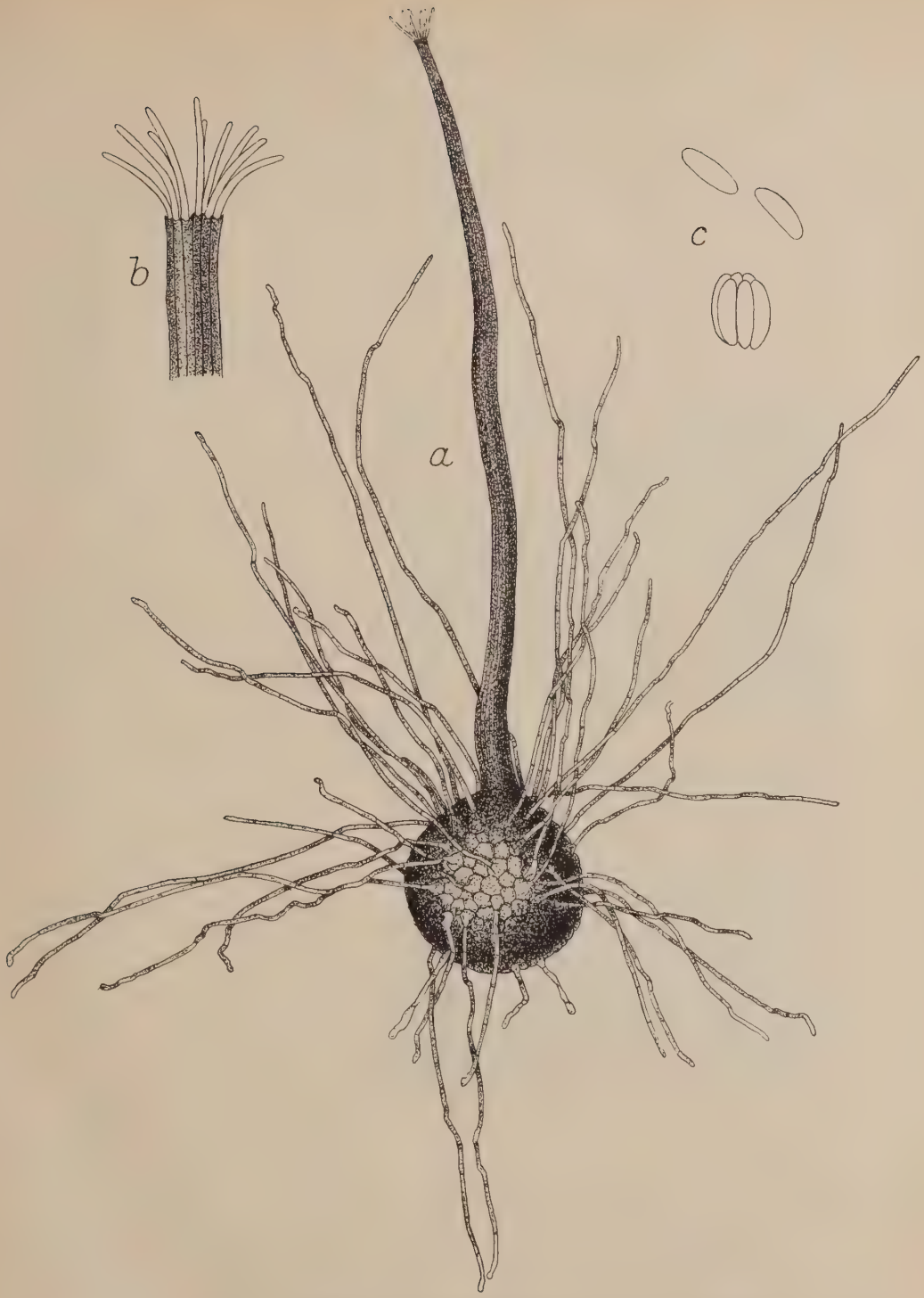


Fig. 23. *Endoconidiophora cœrulescens*. *a*. Ripe perithecium (× 180). *b*. Fringe of cilia (× 630). *c*. Spores (× 2175).

a. Moget perithecium (× 180). *b*. Ciliekrans (× 630). *c*. Sporer (× 2175).

olive-green to black-green. After about 10 days the reproductory stages of the fungus make their appearance.

A grey-green air-mycelium develops in pure cultures on wood, but this assumes a dark colour and turns almost black under optimal development. In our pure cultures it grew somewhat more vigorously on pine than on spruce.

The perithecia are entirely of *Ceratostomella*-type (fig. 23 *a*, 24 *a*). The ventral portion is slightly pear-shaped, the greatest breadth being equal to the height but situated slightly below the centre of the latter. The variation in these measurements is not very large, the limit-values measured being 168 and 208 μ. The remarkbly plentiful and long ventral hairs are striking. Their course is somewhat sinuous, the length can reach something like 240 μ and the thickness rarely exceeds 4 μ. The necks are generally arcuate and appear only exceptionally to exceed 1 mm. in length. Our measurements have shown a variation of between 560 and 1,059 μ. Even of this species it may be stated that the cervical and ventral measures vary quite independently of each other. The width of the neck is 32—48 μ at the base, below the cilia about 10 μ. The later are comparatively few in number, on an average about 10; their length varies fairly considerably

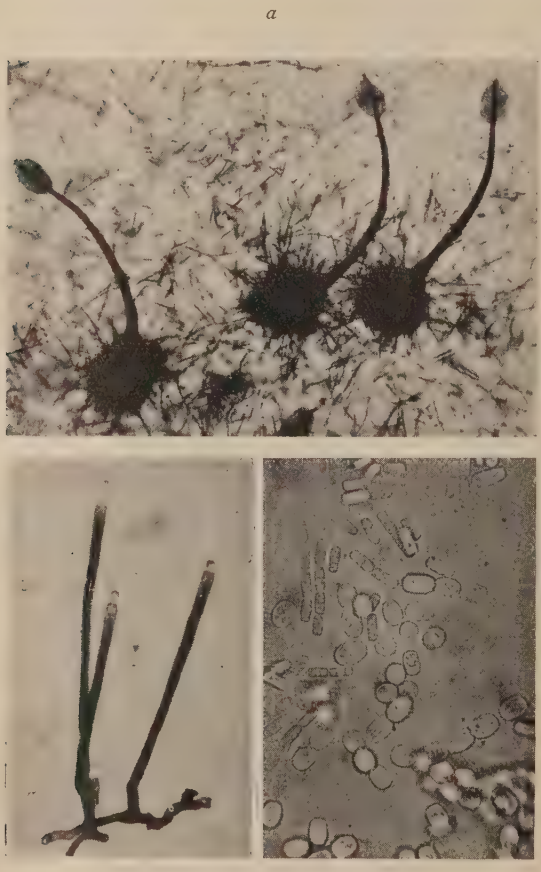


Photo by T. Lagerberg.

Fig. 24. *Endoconidiophora cærulescens*. *a*. Perithecia with expelled masses of spores in a tangle of straight, conidia developing hyphæ (× 500). *b*. Conidial stage, *Chalara Ungeri* (× 115). *c*. Conidia (× 580).

a. Perithecier med utpressade spormassor i en filt av raka, konidiebildande hyfer (× 50). *b*. Konidiestadium, *Chalara Ungeri* (× 115). *c*. Konidier (× 580).

within one and the same fringe, e. g. between 14,4 and 28,8 μ or between 17,2 and 25,6 μ. They are twice as thick at the base as at the apex, 3,2 and 1,6 μ respectively. But occasionally they are quite even. The greatest length measured is 30 μ.

The spores (fig. 23 *c*) are of the *Ceratostomella*-type, but much larger than in the previously treated species of this genus. They are emitted in bunches joined together in packets in a mucous mass which finally flows down along the neck of ihe perithecium (fig. 24 *a*). Their length varies between 7,4 and 9,3 μ, with a corresponding thickness of 1,9 and 2,6 μ. MÜNCH (1907, p. 565) states as an average 7×2 μ.

The conidial formation in *Endoconidiophora cœrulescens* occurs only in one way, and this differs completely from that which occurs in the genus *Ceratostomella*. Compact, straight and non-ramified hyphæ, with firm, dark-brown membranes and almost hyaline apices, grow from the superficiai substratum hyphæ. They appear to the naked eye as an almost black, velvety felt, which supplies also a good characteristic of the species. The apex-cells in these filaments have a double membrane. After de outer, thicker lamella has opened at the apex it remains as a tubular receptacle from whose orifice the conidia soon begin to make their appearance (fig. 24 *b*, fig. 25) in an uninterrupted succession and joined in moniliform chains. Finally they become so plentiful that one can see them without difficulty as a white powder on the black coating of hyphæ. The conidial formation is therefore endogenous. MÜNCH (1907, p. 567) has given an exhaustive description of its course of development and has demonstrated that this stage is identical with the *Chalara Ungeri* described by SACCARDO. The tubular orifice is occasionally quite abrupt and sharp; often it is serrated and uneven, and many times rolled back like a collar. The thickness of the hyphæ below the orifice varies between 3,7 and 8,4 μ (MÜNCH states 4 and 6 μ).

Fig. 25. *Endoconidiophora cœrulescens*. Conidia developing hypha (× 2175). Konidiebildande hyf (× 2175).

Endogenous development of the conidia occurs, as is wellknown, in various lower species of fungi, and several genera have been founded on mycelia possessing this reproductive method. BREFELD (1891, p. 188, pl. V, fig. 51) has found it also in another pyromycete, viz. *Hypomyces asterophorus*, which for this reason he sets up as type for the new genus

Pyxidiophora. It is after this prototype that MÜNCH has established his genus *Endoconidiophora*. In this connection it may be of interest to draw attention to a statement made by HARTIG (1878, p. 74 pl. XI, fig. 9). From a wound-decay on pine he draws a figure of a brown mycelium which in his opinion had perforated the tracheid-walls in many places. In this mycelium occur short, straight hyphal branches with a slightly angustate top-cell which at the apex is infundibular and open, and from this orifice conidia issue. HARTIG identifies the fungus with WILLKOMM's *Xenodochus ligniperda*, which in another connection he wants to join with »*Ceratostoma piliferum*», as mentioned in the introduction. But it is certainly an independent form. There exists a certain similarity with *Chalara Ungeri*, but the chlamydosporous development which HARTIG depicts in his fungus does not permit of their being brought together.

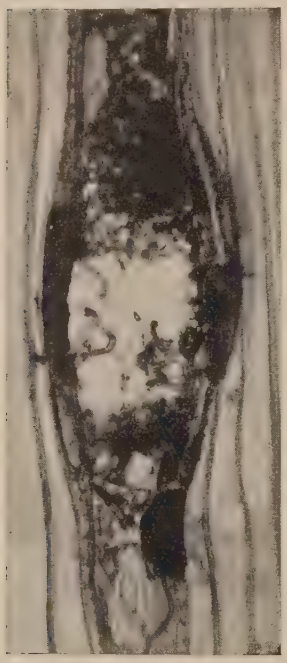


Photo by T. Lagerberg.

Fig. 26. *Endoconidiophora cœrulescens*. Vertical resin-duct in spruce, filled with hyphæ. The secretory cells crowded with pseudoparenchymatous masses of hyphæ, black in the picture (× 115).

Vertikal hartsgång i granved, fylld av hyfer. De sekretoriska cellerna fullpackade av pseudoparenkymlika hyfmassor, svarta å bilden (× 115).

The conidia in *Endoconidiophora* vary greatly as to shape and size (fig. 24 *c*). MÜNCH (1907, p. 568) gives their thickness as between 4 and 5,5 μ. The length he has found to depend on the substratum; under favourable conditions of nourishment it was as much as 5 times the thickness, but with lack of nourishment such a great shortening occurred that the length could even fall below the thickness. Our own observations point in the same direction. In cultures on spruce-wood the conidia were thus on the whole of uniform size, 5,4—7,1 μ long and 5,4 μ thick, but even the elongated, cylindrical shape, e. g. 21,4 × 6,7 μ, was developed here. On malt-agar still longer conidia are sometimes developed, as much as 69 × 5 μ have been measured, but the thickness is here subjected to fairly slight variations. The shorter types of conidia on this substratum are throughout larger than those developed on wood.

The course of development of the fungus in wood differ in one respect slightly from that of the *Ceratostomella*-species. The microscopic picture proves at once that the hyphæ easily grow longitudinaly through

the tracheids, and the character of the fungus as a parenchyma fungus is therefore not so manifest. In the original material (spruce) from Garpenberg plenty of hyphae were found, but they were rather sparse in the live cells of the pith-rays. The membrane was rather faintly brown and had here and there granular exudations. The membranes of the pits of the parenchyma cells were distinctly brown-stained, but otherwise the walls were quite unaffected. The vertical hyphae which were everywhere plentiful and dark-brown grew for long stretches straight and non-ramified through the tracheal lumina, and the narrower tracheids of the autumn-wood were often quite replete. A peculiar feature is the ramification which one can witness here and there in the slides. It really looks as if the bordered pits of the tracheids exercised a localising influence upon the development of the branches of the vertical hyphæ. It can happen that such a hypha for some distance throws out a branch in the centre of every pit; the branches penetrate into the cavities of the pits but stop dead there. They certainly often grow around the edge of the lenticular hollow and finally fill the same more or less completely, but they remain shut up. This may seem peculiar, as in other cases the pits are easily penetrated by the hyphæ. This fungus is incapable of direct perforation. In the spring-tracheids the hyphæ have a thickness of 15 μ. Their course is here on account of the better space slightly sinuous. Here and there lateral, dendritic systems of ramifications of narrow (3—4 μ) hyphæ occur. They often develop profusely (fig. 25) in the hollows of the vertical resin-ducts. Locally floccose hanks develop here, which block the passage and entirely fill the secretory cells. The membrane of the latter is in such cases always brown in colour.

All the aforesaid details were repeated in our pure cultures on spruce. The fungus penetrated the sectors of wood altogether in 3 weeks (Plate I), but the discoloration was not very intense and had a greyish tint. The development was much stronger in pine, and the discoloration grey-black. Not even the piece of heart-wood of the inoculated sector was free from hyphæ. There is nothing really new to add regarding their behaviour in this kind of timber.

The aforesaid observations concerning the manner of growth of the fungus in timber agree apparently fully with the experiences gained in respect of its development in live trunks in nature. The rapid longitudinal growth of the »blaze-blueing» should certainly be looked at against the background that the hyphæ can penetrate through the tracheid levels for long distances independent of the pith-rays.

B. Species of the Sphaeropsidaceæ.

Sclerophoma entoxylina LAGERBERG et MELIN n. sp.

We have hitherto obtained this previously unknown blueing fungus only from the following localities.

1. Gästrikland. Skutskär, 8. 9. 1925. Spruce plank from the timber-yard.
2. Värmland, Skoghall Works, 23. 11. 1925. Pine plank from the timber-yard.

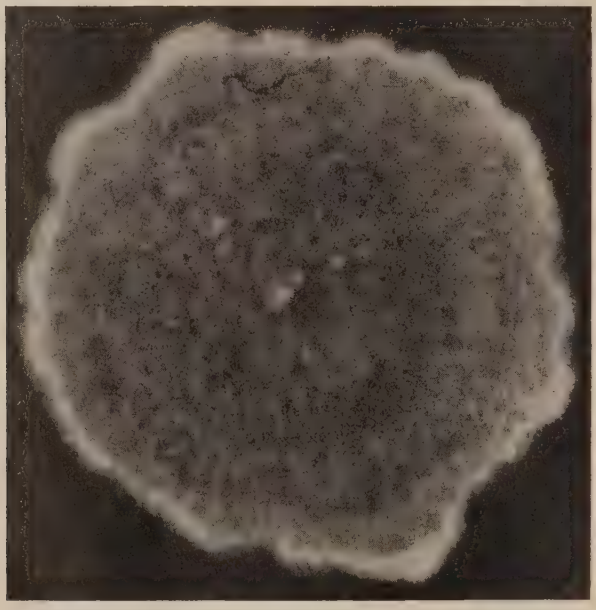


Photo by E. Melin.

Fig. 27. *Sclerophoma entoxylina.* Pure culture on malt-agar (× 1,3).
Renkultur på maltagar (× 1,3).

Although we do not as yet know this species from more than two localities, there is yet every reason to believe that it is very widely distributed. As a blueing fungus it occupies, however, in several respects a peculiar position and is for that reason worthy of particular attention.

On malt-agar an air-mycelium which is at first white and floccose is developed, and this gradually assumes a grey-green and finally a grey-brown colour (fig. 27); the colonies turn brown on the under-side. Their rate of growth (cf. note p. 164) is 4,5, and the fungus therefore does not belong to the slowest forms. The younger, 2—3 μ thick, hyaline

and longicellular hyphæ in the apices often grow to short systems of ramification, among which are included short, irregularly inflated cells (fig. 28 *a*). Older mycelia have rust-brown hyphæ, but their walls remain thin and transparent for some time; finally they are, however, enclosed in a fairly coarse-grained exudation. As the shape of the cell generally remains elongated, constrictions occur on the transverse walls and some of the cells get globular inflations at one end. In agar-cultures peculiar condensations in the mycelium occur already at an early stage, and these

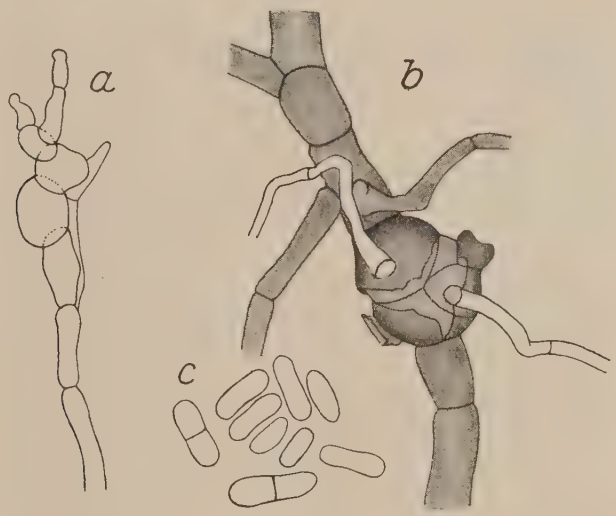


Fig. 28. *Sclerophoma entoxylina*. *a*. Terminal piece of hypha from the air-mycelium (× 630). *b*. Older hypha with germinating chlamydospore (× 630). *c*. Conidia from pycnidium (× 1200). Pure culture on malt-agar.

a. Ändstycke av hyf från luftmycelet (× 630). *b*. Äldre hyf med groende chlamydospor (× 630). *c*. Konidier ur pyknid (× 1200). Renkultur på maltagar.

can be discerned by the nacked eye as black crusts. They consist of broad, brevicellular hyphæ which grow in parallel fascicles and appear to be instilled into a dark-brown mass. The latter originates through the commingling of the membranous exudation from the different hyphæ.

In older hyphæ the formation of chlamydospores is quite common. The chlamydospores are very much enlarged and clearly determinate cells, which are transformed into cellular bodies through secondary walls. Their quiescent period does not seem to be very protracted, for they are not infrequently found germinating. The outer membranous lamella is thereby disrupted into irregular laminæ (fig. 28 *b*).

The prematurely occurring, fairly clearly determinate stromata are important for identifying the fungus. They consist of a pseudoparenchymatous, brown-cellular wall, a few layers of cells thick, which without any sharp delineation passes over into a core of thin-walled and hyaline cells. On crushing such a stroma under the cover-glass one obtains as a rule single conidia free in the water; in older cultures it is possible to convince oneself that the stromata have developed into pycnidia. Their shape is then generally almost globular, but the size varies very much. According to our measurements the diameter is from 150 to over 300 μ.

As it was found impossible to gain a clear insight into the nature of the conidial formation on live material, it was necessary to try and obtain this knowledge on a series of microtome sections. Pieces of mycelium with pycnidia were fixed in picroformol and embedded in paraffin. The 4 μ thick sections were stained with safranin, gentian violet an orange G. A detailed study of these slides gave interesting results. The pycnidia were replete with compact masses of conidia. Close to the wall were remnants of the original stromatous tissues, and one could see here that conidia generated within the cells and were released through the dissolution of their walls. The conidial formation was therefore endogenous. As a rule probably only one conidium appears within each cell, but sometimes two seemed to have developed.

A pycnidium with this peculiar form of conidial development was observed the first time by VON HÖHNEL (1909, p. 1236 et seq). He proves that in reality, although overlooked, it occurred in various previously described pycnidia — *Phoma pithyophila* (Corda) Sacc., *Sphæropsis acicola* Lév., *Pycnis pinicola* Zopf, *Sphæropsis pithya* Thümen, *Sphæronema Piceæ* Friedler, *Sphæronema Pini* (Desm.) Sacc., and he classifies them all under the new genus *Sclerophoma*. The three first-mentioned species are here regarded as synonyms. In this genus must also be included the blueing fungus referred to, inasmuch as in the development of its pycnidia it coincides fully with the type discovered by VON HÖHNEL. The conidia are colourless, unicellular with roundly-obtuse ends, one of which is sometimes a trifle thicker. Their length varies between 6 and 9 μ, the breadth is about 3 μ. In solitary cases we have also seen such as had become bicellular (fig. 28 *c*) through a thin partition wall. The conidia are released through the bursting of the peridium. As we have been unable to decide whether our fungus may be identical with any one of the *Sclerophoma*-species, which VON HÖHNEL includes in his description we have, especially in respect of its occurrence, considered it appropriate to describe it as a new species.

Transplanted on wood *Sclerophoma entoxylina* develops very vigorously

The inoculated tangential surface is coated with a compact, grey air-mycelium, in which numerous pycnidia are established. The strongest growth occurs on pine, whose sapwood throughout assumes an intense black-grey colour (Plate II). Here one can find a remarkably profuse development of hyphæ, both in parenchyma cells and tracheids. The pith-rays are thus penetrated by straight, parallel hyphæ up to 15 μ thick (fig. 29), whose elongated cells contain a few large and spherical drops of oil. The membrane is thin, greyish olive-brown, smooth and without

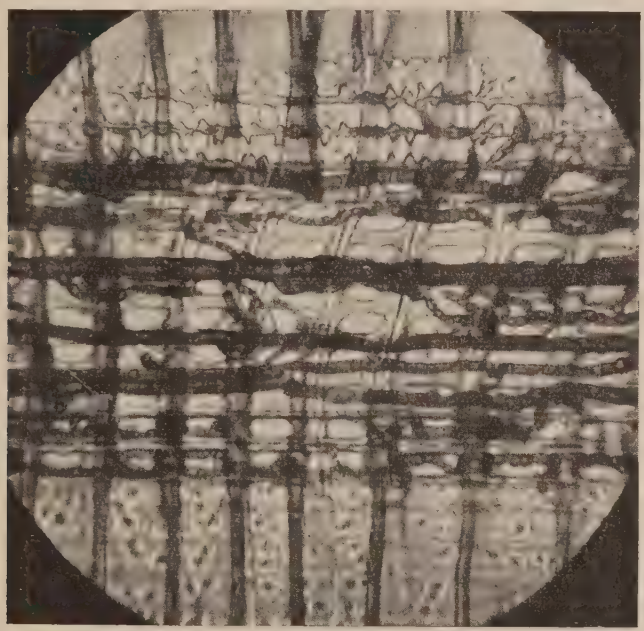


Photo by T. Lagerberg.

Fig. 29. *Sclerophoma entoxylina*. Pith-ray in pine-wood, whose parenchyma cells have been completely devoured by the coarse hyphæ (× 115). Pure culture.

Märgstråle i tallved, vars parenkymceller fullständigt förtärts av de grova svamphyferna (× 115). Renkultur.

exudations. The hyphæ which grow in the tracheids are of another type. Their thickness is about 7 μ, and their course is rather sinuous. The cells have a different appearance, either elongated and dumb-bell shaped with more or less spherical terminal pieces, each one containing a large drop of oil, or the hyphæ are composed of spherical cells. In both cases they remind one of a necklace.

In its behaviour in wood as a substratum *Sclerophoma entoxylina* is especially remarkable. It is perfectly clear that the fungus not only

lives upon the plasma and assimilatives of the parenchyma cells but also devours the non-lignified walls of the cells. After a period of growth of 3 weeks it has thus in pine-wood removed every trace of the parenchyma cells of the pith-rays, and the large angular pits of the tracheids which in this way have lost their membranes, are wide-open (cf. fig. 28). Von Schrenk (work cited, p. 18) already believed to have discovered that *Ceratostomella pilifera* had the capacity of dissolving the walls of the parenchyma cells, although imperfect observations were certainly at the bottom of the conception. Münch (1908, p. 301) also proved later on that these walls are not attacked by the *Ceratostomella*-species, although on account of the great deformation of the cells and the dark discoloration of the disintegrating products of the contents they do not always stand out clearly against the brown masses of hyphæ. This perfectly correct statement does not, as mentioned above, apply to *Sclerophoma entoxylina*.

Amongst the abundant hyphæ in the tracheids there occur occasionally thick ones with barrel-shaped, tumoured cells. Here and there one can observe a kind of chlamydosporous formation which finds expression in some cells in a row being isolated from a hypha through complete resorption of contiguous rows of cells. The hyphæ pass as a rule through the bordered pits from one tracheid to another, but direct perforations of the walls also occur both in spring and autumn-wood, yet always extremely fine. The adpressoria occasioned are spherically tumoured.

Even in spruce the fungus causes an intense discoloration with a black-grey, slightly bluish tint. The hyphæ develop here in about the same way as in pine. The groups of dumb-bell shaped cells seem, however, to be less common, but they have been observed in the hollow of both the vertical and horizontal resin-ducts. In the parenchyma cells the hyphæ are generally about 7 μ thick, but locally twice this measure may be attained. The tracheids contain thick, somewhat sinuous and hardly ramified hyphæ, generally only a single one in each. The direct perforations seem to be somewhat less common.

As our observations from pure cultures on pine-wood, as mentioned, indicated that *Sclerophoma entoxylina* was able to dissolve cellulose, it seemed to us to be of interest to test experimentally this quality of the fungus a little more closely. For that reason we have put it into culture with pure cellelose (filtering paper) as the only carbon source; any other nourishment required was supplied in an aquæous solution. The filtering paper was gradually coated with a fairly sparse, rusty-brown mycelium, in which crowds or sclerotia and pycnidia developed, but it appeared ocularly to be little affected by the fungoid vegetation. When

the test was interrupted after a few months, and the papers removed from their Erlenmeyer retorts, it was found, however, that they had become extremely brittle. It could also be seen with the microscope that the fibres of the paper, which had been partly penetrated by the hyphæ, were more or less strongly affected. In some the wall was finely cleft by spiral-shaped cracks; others, however, seemed to be still entire. At any rate the fibres had altogether been chemically changed, to judge from the colour-reaction obtained with chlor-iodide of zinc; the normal violet cellulose-reaction was entirely absent, and an intense claret colour, which, as is known, is characteristic of amylodextrine when treated with the same reagent, made its appearance. It seems therefore evident that the fungus had utilised the cellulose for satisfying its requirement of carbon, and that the same in this process had undergone rather radica chemical changes. In other words the result of the tests confirms the observations made on the behaviour of the fungus in relation to the non-lignified cell-membranes of the wood.

Sclerophoma entoxylina LAGERBERG et MELIN n. sp.

Hyphis entoxylinis, olivaceis, ligni præcipue *Pini silvestris* colorem in griseo-atrum mutantibus, ad 15 μ latis, cellulis sæpe elongatis et in utroque apice globoso-inflatis, vel brevibus omnio globosis. Pycnidiis minutis, 150—300 μ diam. Conidiis uni- vel raro bicellularibus, 6 × 9 μ.

Discula pinicola (NAUMOV) PETRAK.

This fungus which is probably common with us has been identified, thanks to the kind assistance of the Dr. F. PETRAK, the eminent expert on the *Sphæropsideæ*. We hasten to express our gratitude for the valuable help he has thus given to us.

In our original opinion we had here to do with a species of the genus *Cytosporella*. If one takes, however, regard to the forms which have hitherto been classified under this genus, the same stands out as quite a heterogeneous phenomenon of doubtfully systematic value. If the same, as Dr. PETRAK surmises, will have to be restricted in a future review to embrace conidial stages of species of the melanconidial genus *Valsaria*, our fungus cannot reasonably be a *Cytosporella*. In reality it can without difficulty be classified amongst the genus *Discula*. This was established by SACCARDO (1884, p. 674) for such *Discella*-species as possessed unicellular, elongated and hyaline conidia. The genus has afterwards been minutely characterised by VON HÖHNEL (1915, pp. 133—135) who supplies the following diagnosis of the same: »Stromata developed in and under the epidermis or periderm, cushion-shaped, brevicellular, parenchymatous, with a single or more or less divided or partitioned cavity, outwardly brown to black. Conidiophores simple,

generally subuliform. Conidia unicellular, hyaline, elongated, of medium size. Orifice missing, but the cavity obtains on top a rounded opening or bursts irregularly». The description fits our fungus completely, which will be seen from the following account.

Amongst the *Discula*-species *D. Platani* (Peck) Sacc. is particularly well-known through KLEBAHN's (1905, p. 540 et seq.) researches. It is described as a unilocular, lenticular pycnidium which develops under the lenticells on young branches of plane-trees. A more advanced stage occurs on the fallen leaves. It has been described under the name of *Sporonema Platani* Bäumler and *Fusicoccum veronense* C. Massal. and differs really only through its larger size and the more or less complete division of the cavity through projecting bars. The figures by which KLEBAHN has illustrated the general organisation of the fungus (work cited, p. 548, fig. 45—48, 50) indicate a manifest agreement with our blueing fungus. One can almost take for granted that closer studies and tests will also appoint it to a definite place in the system as the conidial stage of some sac-fungus; we are, however, unable to state anything to this effect for the moment. KLEBAHN has proved *Discula Platani* to belong to *Gnomonia veneta*.

None of the fungi referred to the genus-*Discula* appears to be identical with our species. As the same to all appearances must be common, one might surmise that it had already been observed and also described, possibly as some *Phoma* or *Dothiorella*; we have, however, not considered it worth while to try and determine this merely with the guidance of short and often rather vague descriptions.

Dr. PETRAK has now drawn our attention to a form of fungus which in the preceding year has been described from Russia by Prof. N. A. NAUMOV (1926, p. 6.) in Leningrad under the name of *Ligniella pinicola*, and considers it probable that the latter may be identical with our species. For this reason we have applied to Prof. NAUMOV who has very kindly sent us a copy of his treatise, which is not obtainable in Sweden, and also some original material of his fungus. After we have had an opportunity to peruse his description and also subjected the material to a comparative examination, we have been able to confirm that perfect identity exists between the Russian and the Swedish fungus. The conidial measurements quoted for the former (3,3—4,1 × 1,7 μ) are certainly low, but this statement is corrected already through the 1 000 times enlarged conidia reproduced by the author, whose actual size may be estimated to be about 6,5 × 2,5 μ; the measurements of conidia from the Russian material, carried out by us, have also proved that the latter magnitude is most common. There exists thus really also a perfect

agreement between the Russian and Swedish fungus in respect of the size of the conidia.

As a final result of this systematical research our blueing fungus will therefore be called *Discula pinicola* (Naumov) Petrak.

Our pure cultures have demonstrated that two biologically separate types of the same occur, which for several reasons it may be advisable to treat separately. The main type is thus characterised by a profuse and rapid pycnidial development and the absence of sclerotial formations of mycelia, while the other type, which we have called var. *mammosa*, develops pycnidia extremely sparsely and only after a longer period of culture, but by way of compensation all the more sclerotia (cf. fig. 31). There is no difference in the wood blueing capacity of the two forms. A list of the localities where the fungus has been discovered follows here below:

The main form.

1. Dalecarlia, Garpenberg, 29. 7. 1923, and Nov. 1925. From blued pine-logs which formed part and parcel of the storage tests, in the latter case with developed pycnidia.

Var. *mammosa*.

1. Dalecarlia, Garpenberg, 29. 7 and 16. 11. 1923. From pine and spruce-logs, both winter and spring-felled, included in the storage tests.
2. Stockholm, Saltsjöbaden, 10. 10. 1924. From 4-year old pine branches on an old tree, all severely attacked and probably also killed by bark-beetles.
3. Dalecarlia Garpenberg, 3.4.1925. From growing, blazed spruce-trunks. The infection had taken place in the blazes. Material received from Mr O. Ekbom.
4. Värmland, Skogshall Works, 26. 7. 1924. From a pine-deal in the timber-yard. — Same locality, Nov. 1925. From sawn pine and spruce-timber; on pine, alone; on spruce partly alone and partly together with *Hormodendrum cladosporioides*.

The most interesting occurrence of *Discula pinicola* is undoubtedly that connected with the live, but blazed spruce-trunks, in which the fungus had been able to cause distinct blueing. They occurred in the Garpenberg State Forest where the extensive blueing ravages by *Endoconidiophora cærulescens* had also been met with (cf. p. 196). We are rendering some observations about this made by Mr. O. Ekbom, who has been kind enough to place them at our disposal. In this connection there ought, however, to be made the reservation that not all the cases mentioned could be verified as to their cause by pure cultures, but that this had to be done by ocular inspection. The *Discula*-blueing develops, as a matter of fact, more slowly, and the discoloration appears more uneven than that caused by *Endoconidiophora*. The latter developed, as far as could be judged, absolutely pure in those trunks that had been attacked,

and was practically the only detrimental fungus in the locality. The *Discula*-blueing, on the other hand, was largely intermixed with blazing decay — caused by *Stereum sanguinolentum* — and could therefore not be studied with the same facility. A relatively pure attack in a forest branded two years earlier gave on investigation the result that 57 % of the trunks were blued, whilst 40 % had decayed. In a 100 year old forest, branded 4 years earlier, the percentage of blueing was 80 and that of decay 14. The same forest had 1 $^1/_2$ year earlier a percentage of blueing of 55 % and the blaze-decay was only of sporadic occurrence. Solitary streaks of blueing were after 4 years as much as 5 meters in length, but were on cross-sections very restricted; the feeblest attacks attained only the thickness of a lead-pencil.

For the purpose of investigating the course of development of the mycelium on malt-agar the type characterised as var. *mammosa* was used exclusively. This forms here at first a light-grey, sparsely floccose, subsequently more or less brown-grey air-mycelium (fig. 30); the under-side of the colonies turns black-green or pure black. The rate of growth (cf. note p. 164) is 3,5. In a 3-weeks old cover-glass culture the hyphæ had assumed a fairly dark, olive-green colour, and on the older ones there appeared numerous although rather sparsely distributed, papillary exudations. These older hyphæ were to a large extent of *Hormisium*-type, i. e. their cells were short and tumurous, occasionally almost spherical, and up to 12 μ thick. Groups of cells of this appearance could have an absolutely smooth membrane, or they were encased in a strong mucous vagina. The ramification was generally very sparse, but the fine branches which had developed grew almost at right angles. The mycelium also displayed a great tendency to develop circular spiral hanks and threads. The latter could become quite strong in time — up to 45 μ in thickness — and appeared both submersed and on the surface of the substratum and in the air-mycelium, where they caused the brownish tint which occured in older colonies. The submersely growing hyphæ are longicellular but irregularly developed in so far as the cells are often curved and have local tumours, or narrow cells (about 3,5 μ) alternate with strongly inflated ones whose diameter is as much as 14 μ (cf. fig. 33 *a*). Such forms of mycelia must really be considered as abnormities.

Conidia could very frequently be met with in slides from one-month old cultures. In most cases they occurred sparely. Unfortunately we have never succeeded in determining how they developed. They are unicellular and hyaline, protractedly fusiform with pointed ends, and differ through their slightly greater length from those that are developed

in the pycnidia of the fungus. The measurements made indicate a variation in length between 6,5 and 9,3 μ, and in thickness between 2,3 and 2,8 μ. One might feel inclined to believe that the sporadically occurring conidia had something to do with the formation of sclerotia which are quite soon established in the air-mycelium of the fungus, but such is not the case. In tube-cultures scattered, black pulvilli are deve-

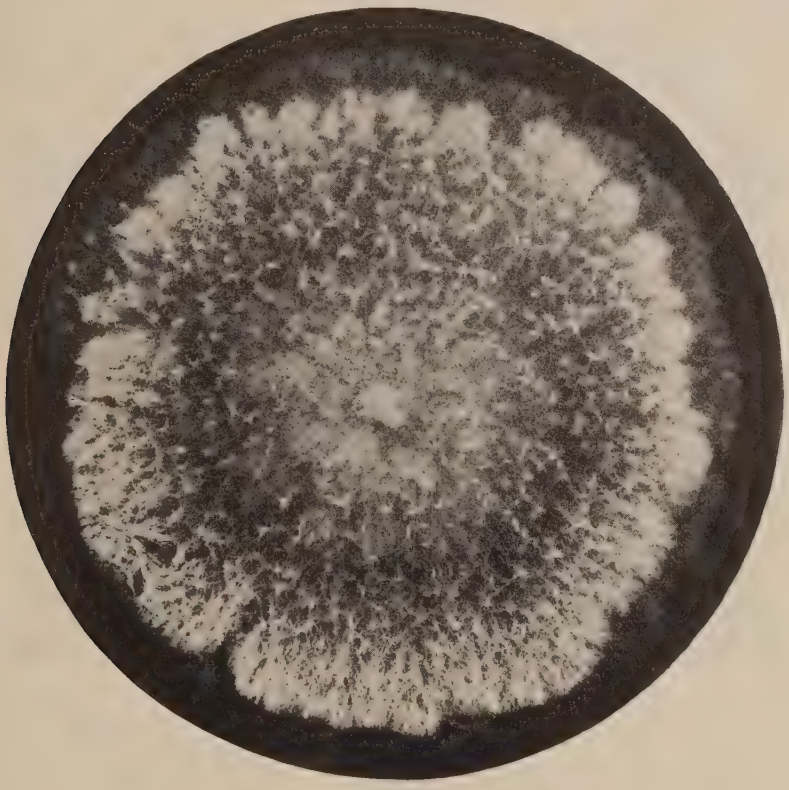


Photo by E. Melin.

Fig. 30. *Discula pinicola.* Pure culture on malt-agar (× 1,4).
Renkultur på maltagar (× 1,4).

loped from those hyphæ which have grown on the glass walls. They consist chiefly of fine, about 2,5 μ thick, densely tangled hyphæ without any trace of conidial formation. On the other hand they contain masses of calcium oxalate crystals. In the plate-cultures there appear as a direct development of such inceptions firmer, well-delineated, pulvilliform sclerotia (fig. 31). They attain sometimes a diameter of 2 mm., and get a finely capillose surface, and they impart to the cultures a remarkably characteristic appearance. They must probably be conceived

as stromatous formations in which for some reason no pycnidia appear. As a matter of fact the majority never change their structure; their pseudoparenchymatous structure remains the same, no matter how long the cultures are allowed to grow and it may even happen that pycnidia are never developed. This has, for example, been the case with the strain of the fungus which had been isolated from the Skoghall Works in 1924. In other strains, however, pycnidia in some stromata may, as has been mentioned, appear after a long period of growth, perhaps after 6 months or more. They reveal their presence by the conidial

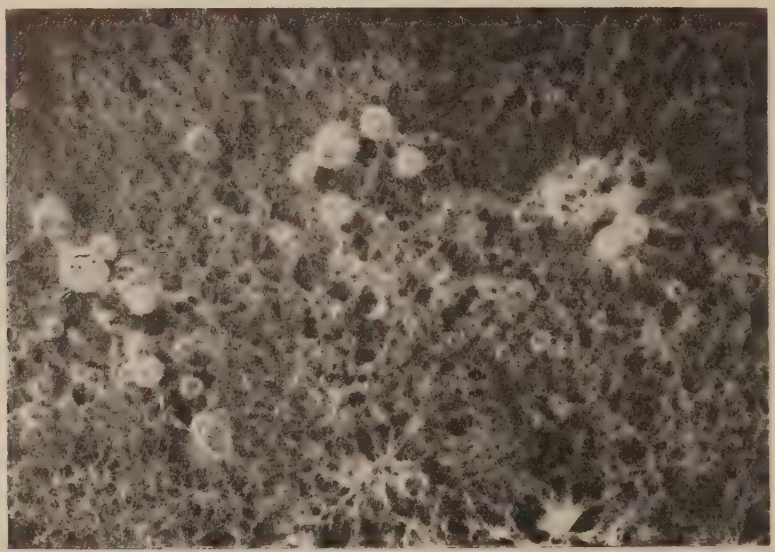


Photo by E. Melin.

Fig. 31. *Discula pinicola* var. *mammosa*. Portion of air-mycelium with pulvilliform sclerotia (× 3). Pure culture on malt-agar.
Parti av luftmycel med dynlika sklerotier (× 3). Renkultur på maltagar.

mass emitted, which rests upon the stroma as a pale, flesh-coloured drop. The commonest size of these conidia is about $5{,}6 \times 3{,}7\ \mu$, but both smaller and those of a more elongated type occur.

The development of the pycnidia has been studied on microtome sectioned material from pure cultures on malt-agar. A section through a pycnidiferous stroma leaves a quite confused impression (fig. 32). It shows a number of cavities of very varying size, the smaller ones almost spherical, the larger ones with a more irregular shape and more or less deeply lobated by injutting bars and beadings. It seems as if these complicated pycnidia at least partly originate in such a manner that several

originally separate cavities open into each other through the collapse of the joint, pseudoparenchymatous wall, and that this collapse is caused by the increased pressure which the growing conidial mass is exercising. No matter how large the receptacles may be, one finds them always crowded with conidia. When the outer wall gives way, the conidial formation evidently continues undiminished for quite a long time, for the guttate conidial mass which issues becomes finally quite large.

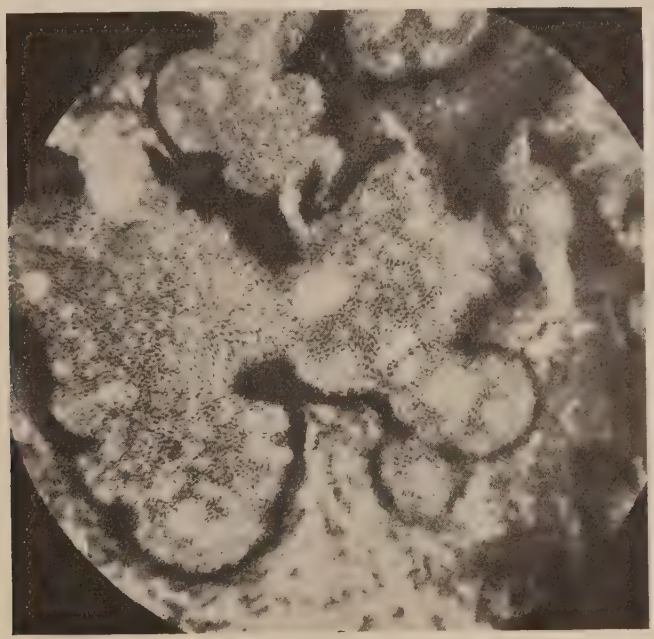


Photo by T. Lagerberg.

Fig. 32. *Discula pinicola*. Microtome section through pycnidium from a pure culture on malt-agar (× 115).
Mikrotomsnitt genom pyknid från en renkultur på maltagar (× 115).

The details of the conidial formation can be observed fairly easily on free-hand sectioned, live material and, of course, also on microtome slides. The pycnidial wall is quite thin and composed of narrow hyphæ, the outer ones appearing to be more elongated. The innermost layer is more pronouncedly parenchymatous, extremely thin-walled, and its outermost plasma-filled cells grow in short, subuliform monocellular sterigmata from whose apices conidia are budding (fig. 33 *b*). The conidial formation is probably iterated. It could be very distinctly seen on the fixed and coloured material, that all the conidia contain 2 nuclei, one in each end. The nuclear conditions of the hyphæ could,

however, not be investigated, partly on account of the dark colour of the membranes and partly on account of the plentiful cellular contents.

The aforesaid description applies, as mentioned, to var. *mammosa* of *Discula pinicola*. There is really nothing new to be added about the profusely pycnidiferous main type such as developed in agar-cultures, with the exception of the ocularly discernible differences which have already been pointed out.

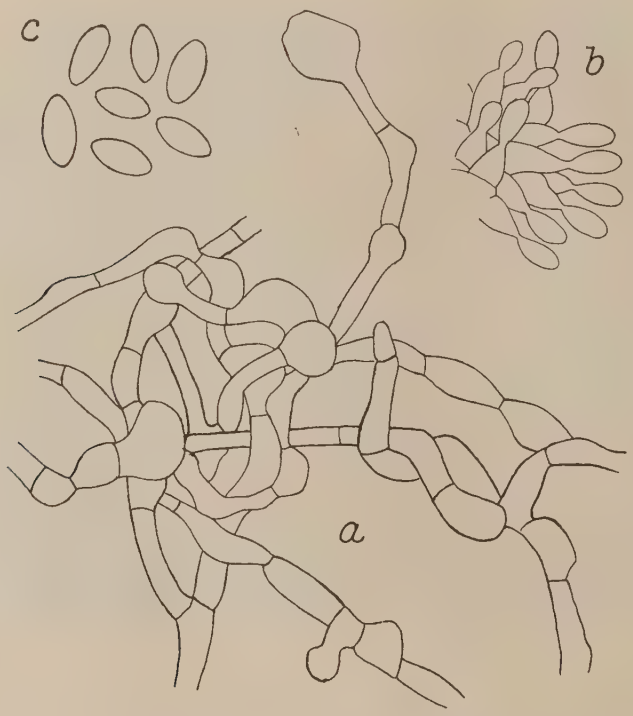


Fig. 33. *Discula pinicola*. *a*. Forms of hyphæ from a cover-glass culture (× 1200). *b*. Portion of a pycnidial wall with budding conidiophores (× 1600). *c*. Conidia (× 1600).

a. Hyfformer från en täckglaskultur (× 1200). *b*. Parti av pyknidvägg med konidieavsnörande hyfer (× 1600). *c*. Konidier (× 1600).

We shall now pass on to an account of the behaviour of the two varieties in wood and shall then take var. *mammosa* under consideration first. The latter grows better, and also penetrates slightly quicker in pine than in spruce, even if the difference in the air-mycelium developed is not so great. The inoculated tangential surface of a sector of pine-wood was in a short time vested in a light-grey, lanated mycelium, through which the discoloured surface of the wood looked grey-green. In this

hyphal coating masses of stromata of exactly the same type as those in a the agar-cultures soon develop. On the other hand pycnidia have never been produced in our numerous inoculation tests on wood. After a period of growth of 18 days in ordinary living-room temperature the mycelium had in several instances penetrated 50 mm. into broad-ringed, winter-felled timber, which as a consequence assumed a grey-green colour (cf. Plate I). A multitude of small, black sclerotia appeared on the transverse surfaces of the sectors, and these were on closer examination found to be confined to the openings of the vertical resin-ducts.

The parenchyma of the pith-rays is replete with nearly straight, compact and only slightly ramified hyphæ, and its series of cells undergo violent contractions. The hyphæ are 8 μ thick and their rather faintly-coloured membrane may be sparsely coated with darkbrown laminæ and grains. They also occur plentifully in the tracheids but are much narrower (1—3 μ in diameter); their cells are here elongated and contain moniliformly arranged drops of oil. They pass between the tracheids through the bordered pits. But there exists also a possibility of direct perforation, though it is clearly not made use of to any extent. The perforating hyphæ are moreover so fine that they do not attract immediate attention. In the vertical resin-ducts the fungus grows slightly more strongly, to judge from the darker-coloured membranes and a more profuse exudation upon them. Even in the parenchyma which surrounds the secretory cells distinct hour-glass like contractions appear.

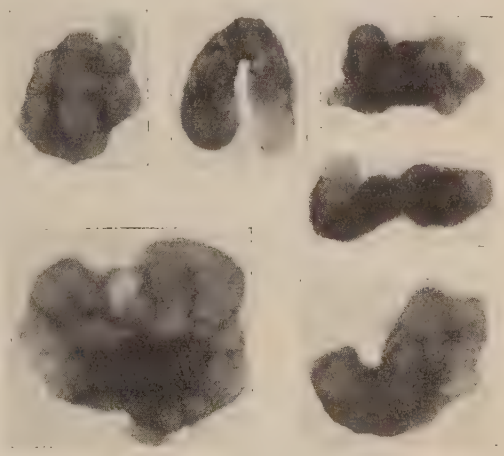


Fig. 34. *Discula pinicola.* Types of pycnidia, developed on tangential surface of an inoculated sector of pine-wood (× 115). Pure culture.

Typer av pyknider, utvecklade på tangentialytan av ett ympat stycke tallved (× 115). Renkultur.

The following details may be mentioned from the tests made on spruce. On the inoculated tangential surface of the sectors numerous, dark sclerotia soon develop from which a whitish mycelium radiates. Qantities of calcium oxalate, both free crystals amongst the hyphæ, and drusy collections on these and within the sclerotia, occur generally. The development of the hyphæ in the wood progresses sometimes in such a way that no blueing, or also a fairly faint one, is caused

(cf. Plate I). They certainly occur profusely both in the pith-rays and in the tracheids, but they are very narrow (1—2 μ), slightly sinuous and ramified, as well as slightly or not at all coloured. The direct wall perforations appeared peculiarly enough to be more common but still very fine; the hyphal piece enclosed in the tracheid wall has a thickness of only 0,3—0,4 μ.

Other inoculation-tests on spruce have resulted in grey-green blueing. The rapidity of penetration of the mycelium was then rather considerable — about 40 mm. in 18 days and in ordinary living-room temperature — but at any rate 10 mm. less than the measurement in simultaneous tests one pine showed.

There remains now an account of the behaviour of the main variety in wood. The differences proper concern here also the pycnidial development. In nature we have found conidial stromata in the dried strips of secondary phloem, which always remain on a wholly barked log. It is obvious that they establish themselves within this tissue, and they appear finally through the bursting of the super-incumbent layers. The shape and direction of the fissure is in this process determined by the anatomical structure of the cortical tissue; it becomes fusiform with clearly aculeated ends and ranges alongside the fibres. The exposed stromatic formations appear coal-black to the eye. The majority are very small — less than $^1/_2$ mm. in diameter — the largest observed by us attain about 1 mm. If this variety of fungus is inoculated upon wood, pine or spruce, entirely superficial stromata of the most varied shape soon appear. This is probably partially due to the uncommon method of establishing (on top of and not in the interior of the substratum), but also to the nature of the pycnidial formation. In fig. 34 some of the various types have been depicted: elongated, botulated, straight or curved more or less pulvilliformly round, and sometimes mulberryshaped on account of the agglomerated and somewhat projecting pycnidial lobes. Several of these stromatic bodies contain only one continuous cavity; this was, for example, the case with the V-shaped type which is illustrated in fig. 34. On the transverse surfaces of the sectors the stromatic pulvilli are developed across the orifices of the amputated resin-ducts, which might possibly be explained by the fact that the growth of the fungus within the wood, and especially in its resin-ducts, is uncommonly vigorous. The vertical resin-ducts can as a matter of fact also be replete with a pycnidiferous stromatic tissue, and for distances of several millimeters in length (fig. 35) one finds thus a brown-celled pseudoparenchyma, perforated by irregular cavities which are crowded with conidia. Even in the wider spring-tracheids stromatic and pyc-

nidial formation of absolutely the same nature occurs. It has even been discovered in spruce timber in the horizontal resin-ducts, although through lack of space it is here kept within very modest limits.

The interior conidial formation must really from the point of view of the fungus be immaterial, inasmuch as it cannot contribute towards the dissemination of the species. *Discula pinicola* is, however, not the

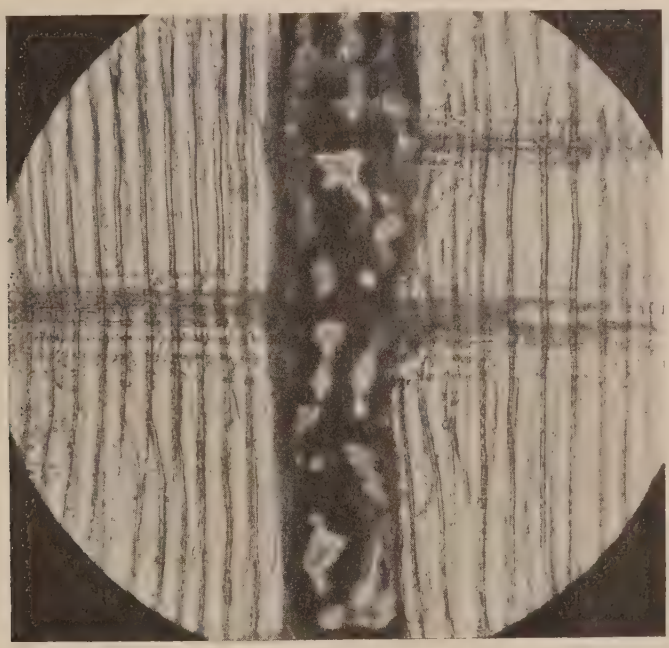


Photo by T. Lagerberg.

Fig. 35. *Discula pinicola*. Vertical resin-duct in pine-wood, filled with a stromatous mass of hyphæ with irregular hollows, in which the conidia are developed (× 115). Pure culture.
Vertikal hartsgång i tallved, utfylld av en stromaartad hyfmassa med oregelbundna håligheter, i vilka konidier bildas (× 115). Renkultur.

only blueing fungus which develops its reproductive stages within the substratum, it rather looks from our researches as if this were in reality quite a common feature.

C. Hyphomycetes.

Hormonema dematioides LAGERBERG et MELIN nov. gen. et sp.

Our blueing researches have enabled us to come into contact with a type of mycelium which through its variety of form presents great

difficulties from a systematical point of view. It belongs to the extremely vaguely defined *Hormiscium — Torula*-series of the *Dematiaceæ* and is obviously closely related to *Dematium pullulans* de Bary et Loew.

The genus *Hormiscium* comprizes sterile mycelia whose more or less moniliform cell-chains have been improperly interpreted as conidial catenations. Regarding this genus it is stated in systematic literature (e. g. in LINDAU, p. 596) that »sterile mycelium is entirely absent or only feebly developed; the fungus consists of hyphæ whose individual cells are developed as 'gemmæ'». Nevertheless, in the case of such bodies as well as in that of conidia the circumstance occurs that they are not isolated for which reason they are actually unable to function as disseminating units of these fungi. According to LINDAU the *Hormiscium* species are only specific myceliary stages of *Ascomycetes*. It is also known that the *Hormiscium*-type can be assumed by the most varying forms of mycelia under certain conditions of nourishment. On the other hand investigations hitherto carried out do not seem to have proved indisputably that any *Hormiscium*-species of a fixed type actually exists. NEGER (1917) who has thoroughly investigated the so called sooty moulds on the leaves of conifers and foliferous trees has distinguished a couple of *Hormiscium*-species, *H. pinophilum* Nees and a form named *Hormiscium* II, as important constituents of the same and points out (p. 104) that they never grow otherwise than as moniliform filaments. If this is correct, HEDGCOCK (1906, p. 101) has aparently made a mistake when he describes his new species *Hormiscium gelatinosum*. This was based on a mycelium which caused an intense black discoloration in the sapwood of pine, elm and *Liquidambar*. The choice of genus was, however, made with a certain amount of hesitation, and the author refers to expert assistance in the solution of the question. As a matter of fact the fungus displayed on the one hand a obvious likeness to *Dematium pullulans* de Bary et Loew, on the other hand the moniliform catenations of »conidia» must also be taken into consideration — which nevertheless are no conidia — of which a good illustration is given on Pl. II, fig. 7, and 8. The latter feature determined the choise of genus; NEGER would certainly not have approved of it.

We ourselves do not feel convinced that *Dematium pullulans* is an entire stranger to the genus *Hormiscium*.

It remains to be seen if not a mycelium which could be acknowledged as a »genuine» *Hormiscium* could be forced to grow with a more elongated type of cells by the selection of a suitable substratum. From NEGER's work it can certainly not be clearly ascertained how highly concentrated a solution he gave to his sooty mould commensals, but as

far as one can understand he has tried to imitate the honey-mildew occurring in nature; such a substratum would, however, probably give a quite one-sided illustration of the possibilities of development of the fungi. In a strongly saccharine nutritive solution *Dematium pullulans* develops mycelium, which in no respect can be distinguished from *Hormiscium*, even such peculiar stages appearing that they can be referred to the genus *Coniothecium*. Maybe one shall be pardoned for doubting a genetic distinction between these myceliar forms intermingled into a coating of sooty mould, when one is able at the same time to prove that one of them is able to produce all of them in pure culture.

In our opinion the method applied by NEGER (1917, p. 85) does not offer sufficient guaranty that the independence of all the mycelia he has had in culture can actually be considered proved. For example, one gets from his description a strong impression of the close relationship between *Hormiscium pinophilum* and the type distinguished as *Dematium* II; the arguments adduced in evidence of the contrary do not seem to us to be quite convincing.

The great trouble to which NEGER has gone in order to ascertain what *Dematium pullulans* really is has hardly been repaid by the result. The fungus seemed to him to be »a real Proteus»; in the many cultures put down of the fragment of sooty moulds the mycelia displayed certain slight differences. NEGER considered that he ought to leave undecided wether these were different varieties of one and the same species or if they were different species. In at least one case he seems to have decided for the latter alternative when he sets up »*Dematium* II» as a form equal to *D. pullulans* upon the basis of differences of an apparently quite inessential nature: imperfect or only feeble capacity of liquefying gelatine, a sparser conidial formation, and absence of budding in the detached conidia.

The heterogeneousness of the *Dematium pullulans*-type is indisputable, and a division of the same on rational bases is quite necessary. In order to elucidate this problem it is in the first instance necessary to dismiss altogether the generic name used of old. The genus *Dematium* established by PERSOON, in which are included about 20 species, has as a matter of fact nothing whatever to do with DE BARY's *Dematium pullulans*. This type of mycelium has peculiarly enough been quite neglected in systematic literature, though it should be worthy of as much attention as many *Hormiscium* and *Torula*-species of whose real nature we know just as little. In order to obviate these difficulties we have deemed it most practicable to establish the new genus *Hormonema* and

allow *Dematium pullulans* in NEGER's description to form the type for the same. The characteristic of the genus is under all circumstances the method of the conidial formation. The conidia are constricted directly from the mycelium without being localised to any particular branches which might be described as conidiophores. They are monocellular, hyaline, or only later on more or less brown-coloured, and they often start budding themselves which may give rise to sticky, yeast-like masses. To this must be added as a characteristic of a more secondary importance the capacity of developing under certain conditions *Hormiscium*- or *Torula*-like stages or even such of *Coniothecium*-type.

The genus *Hormonema* includes thus without NEGER's *Dematium*-species HEDGECOCK's *Hormiscium gelatinosum* as well as 2 species found by us to be independent, of which one, *H. dematioides*, is an important blueing fungus. It has been obtained not only from a number of discoloured specimens of wood but has also been met with as a pure epiphyte on live pine-needles in the park of the College of Forestry. From this is made manifest the interesting fact that blueing in timber and sooty mould is at least partly due to the same or similar kinds of fung. From the same pine-nedles another species of *Hormonema* has been isolated which, however, seems only to boast of a colourless mycelium. This form which for convenience's sake may be callad *Hormonema pallida*, develops on malt-agar dingy yellowish colonies, mainly consisting of sticky masses of conidia. By rights it should maybe for this reason be transferred to the *Mucedineæ*, but as in the nature of the conidial formation and the manner of myceliar growth it agrees completely with the *Hormonema*-type, a separation must be considered as artificial. There is nothing new in the fact that the border between the *Dematiaceæ* and *Mucedineæ* is not natural. It may be worth emphasising the fact that many normally dark-coloured mycelia become colourless under special conditions of development. We merely refer to *Ceratostomella Piceæ* which when growing in wood can be included in the more freakish colour-producers. The reason of the absence of pigmentary formation is probably very complicated. NEGER states in respect of *Dematium pullulans* that the dark colouring of the hyphæ is due to the access of air, and he bases his opinion upon observations from his pure cultures. As a matter of fact the submersedly growing hyphæ remained hyaline, while the superficial ones were black. It has nevertheless been placed beyond doubt that other, less easily discernible causes may also produce colourless hyphæ. In regard to *Hormonema pallida* there is scarcely any reason to assume that it had lost its capacity of developing pigment for the time being, as it had been cultivated on malt-

agar under precisely the same conditions as other blueing fungi whose mycelium is distinguished by an immediate brown colouring.[1]

It is of course not easy to decide if any of NEGER's *Dematia* may be identical with our *Hormonema dematioides*, but the similarity between the latter and his *D. pullulans* cannot be disputed; it may be considered certain that it is identical with HEDGECOCK's *Hormiscium gelatinosum*. We have also reason to believe that *H. dematioides* supplies the solution of WILLKOMM's *Xenodochus ligniperda* (cf. p. 231) which latter has by SACCARDO been transferred to the genus *Torula* (1906, p. 565), and is also by LINDAU (1909, p. 578) considered as a species of *Torula*. Sundry species classified amongst *Hormiscium* have probably also their proper place in the genus *Hormonema*.

The localities from which we have isolated *Hormonema dematioides* are as follows:

1. Dalecarlia, Garpenberg, 29. 7. 1923. From spruce-timber which was included in the storage-tests.
2. Ångermanland, Svanö, August 1925. From sawn pine-timber together with *Ceratostomella cœrulea*. From sawn spruce-timber partly together with *Cadophora fastigiata* and *Hormodendrum cladosporioides*, partly together with *Cadophora* and *Ceratostomella Piceæ*.
3. Västmanland, Bjurfors, 1925. From sawn pine-timber, partly alone and partly together with *Ceratostomella cœrulea*.
4. Gästrikland, Skutskär, September 1925. From sawn pine-timber.
5. Ångermanland, Kramfors, September 1925. From sawn pine-timber.
6. Gästrikland, Bomhus, September 1925. From sawn pine-timber.
7. Värmland, Skoghall Works, November 1925. From sawn spruce-timber together with *Cadophora fastigiata*, *Hormodendrum cladosporioides* and *Penicillium biforme*.
8. College of Forestry Park, December 1926. Isolated from live pine-needles together with the entirely colourless *Hormonema pallida*.

The fungus develops in pure cultures on malt-agar in two quite different ways which is intimately connected with the conidial formation. This can, as a matter of fact, commence practically immediately, and when it is moreover combined with extremely profuse budding, mucous, whitish masses appear which entirely cover the radiating, dark hyphal substratum (fig. 36). The development seems always to go in

[1] Since the above was written it has been proved by the tests continued that also *Hormonema pallida* possesses the capacity to cause blueing. It was inoculated upon sectors of broad-ringed pine-wood with the result that the sapwood a fortnight later was entirely permeated with hyphæ and had by these been coloured faintly grey-green. The discoloration was perfectly even, without the radial streakiness which distinguishes *H. dematioides*. The development of conidia within the wood was common (cf. p. 231). No hyphæ could be macroscopically detected upon the surface of the sapwood.

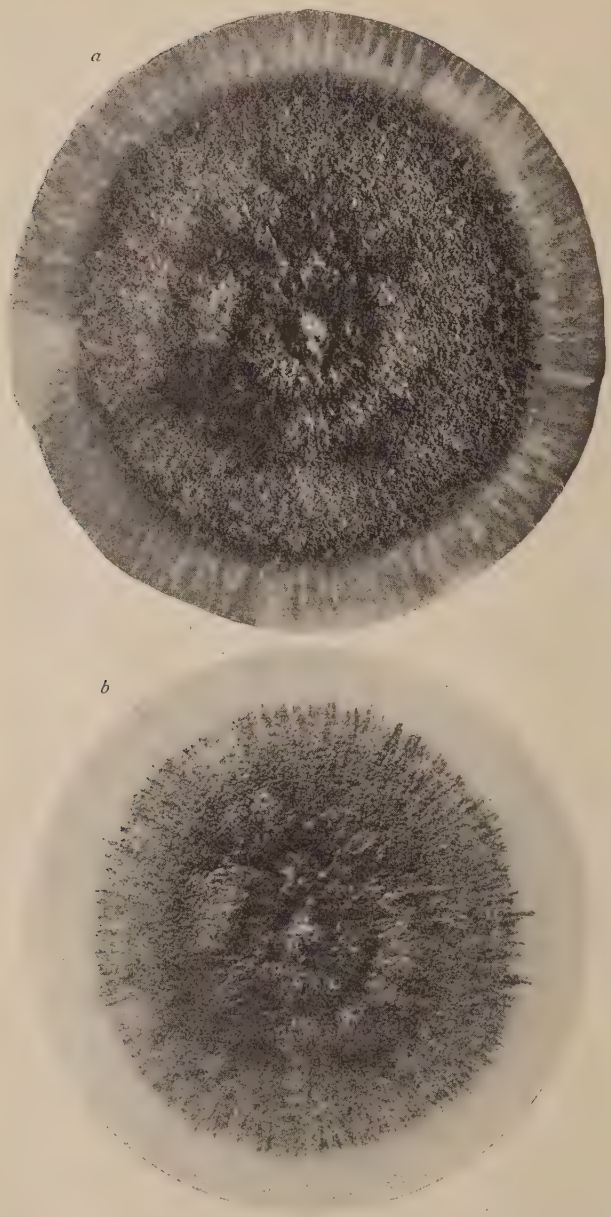


Photo by E. Melin.

Fig. 36. *Hormonema dematioides.* Pure culture on malt-agar obtained from a freshly isolated stock. *a.* Against a dark substratum which allows the colourless marginal zone to be distinguished. *b.* Against a light substratum through which the radial course of the older, dark hyphæ is set off. The surface covered by a sticky mass of conidia. (× 1,3).

Renkultur på maltagar, anlagd från en nyisolerad stam. *a.* Mot mörkt underlag, som låter den ofärgade kantzonen framträda. *b.* Mot ljust underlag, genom vilket de äldre, mörka hyfernas radiära förlopp framhäves. Ytan täckt av en smetig konidiemassa. (× 1,3).

the same direction when the pure cultures are established from freshly isolated strains, but the picture changes in due time. When the cultures are reared from older strains conidia develop only comparatively sparsely, but an olive-green, finally grey-brown to dark-brown, floccose air-mycelium (fig. 37) develops instead. The growth of the fungus is then quite reduced. While its rate of growth as freshly isolated is 5,5 (cf. note p. 164), it is merely 1,2 in the air-mycelium type.

The earlier development has been studied in numerous cover-glass cultures and displays examples of great variation. In some cases the first hyphæ which radiate in all directions grow perfectly straight. Intercalary cellular divisions appear in their proximal portions which immediately assume a dark-brown to blackish olive-green colour, so that the originally elon-

gated cells are replaced by a much larger number of short, more or less disciform ones (fig. 38 *a*). Fairly sparse ramification commences and the branches develop in the same manner as the main axis. Even if the individual cells have slightly bulging walls they are not rotundate, but the transverse wall abuts at a generally sharp angle on the longitudinal wall. Hyphæ of this appearance remind one very much of *Hormiscium pinophilum* Nees such as depicted by LINDAU (1906, p. 598, fig. 2) and NEGER (1917, fig. 7). The agreement is perfect in such cases when the short, brown cells occur right out into the apices of the filaments, but here we generally find narrow, longicellular and colourless portions which continue to grow; in the former case this seems to have stopped.

Photo by E. Melin.

Fig. 37. *Hormonema dematioides*. Pure culture on malt-agar, obtained from an old stock. Strong, lanate air-mycelium, without conidial formation. (× 1,3).

Renkultur på maltagar, anlagd från en gammal stam. Kraftigt, flockigt luftmycel utan konidiebildning. (× 1,3).

The earliest course of development of the fungus has been quite different in other cultures. The hyphæ have immediately assumed a very sinuous manner of growth, and the separate cells have greatly increased in number through intercalary divisions and become rotundate, so that moniliform catenations of *Torula* or *Hormiscium*-type have appeared (fig. 39 *b*). It has, however, been found that this stage has changed after a time and the shape of the cell has assumed greater similarity to the one delineated in fig. 38 *a*. Finally it may also happen that the bulk of the hyphæ retains a more or less elongated cellular shape and the *Hormiscium* or *Torula*-stages are restricted to later established lateral branches whose vertical growth ceases simultaneously (fig. 38 *c*, 39 *c*). It is hardly surprising that such short, moniliform rows of cells as the one drawn in the latter figure have been interpreted as conidial catenations. Fig. 38 *c* agrees perfectly with the conidial catenations of *Hormiscium*-type which HEDGCOCK (1906, Pl. II, fig. 7, 8) mentions and illustrates for his *H. gelatinosum*. All these cells keep, however, together, and after being quiescent for some time develop into new hyphæ (fig. 39 *d*). The wall has then generally managed to

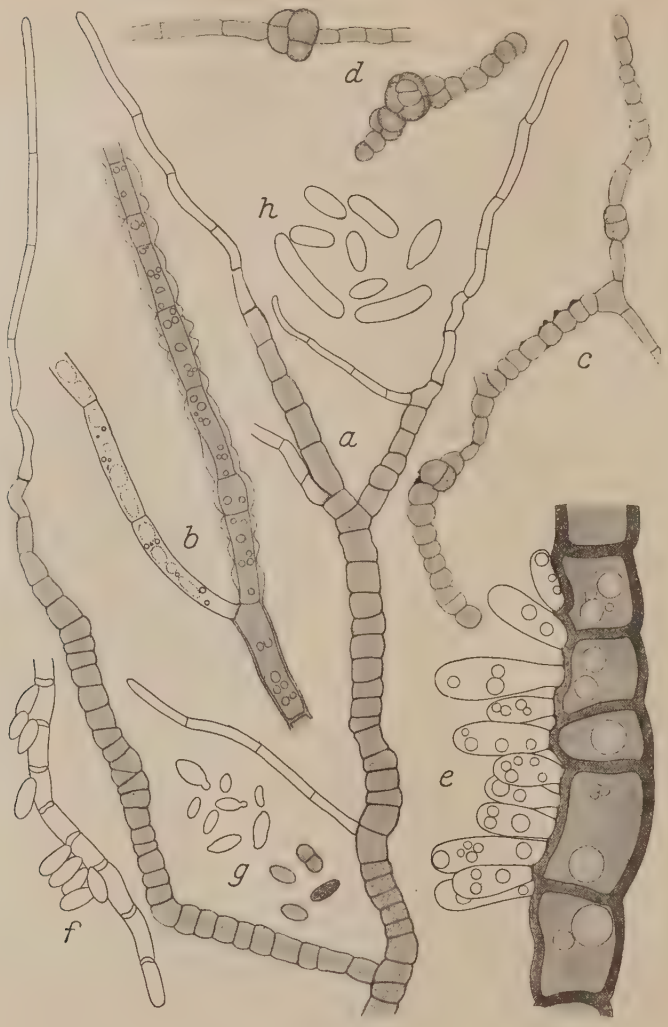


Fig. 38. *Hormonema dematioides*. Strain from spruce-timber. *a*. Young hyphæ before conidial formation has commenced (× 415). *b*. Older hypha with commencing mucification of the membrane (× 745). *c*. Branches of hyphæ of *Hormiscium*-type (× 415). *d*. *Coniothecium*-like cellular bodies (× 415). *e*. Palisade-shaped conidial formation from older hypha (× 1420). *f*. Hypha in a state of resorption with thickend transverse walls like a watch-glass (× 745). *g*. Conidia while budding and older ones with dark-coloured membranes; two of them bicellular (× 415). *h*. Conidia developed within tracheids in pine-wood (× 1420). *a*—*g* from cover-glass cultures.

Stam från granved. *a*. Unga hyfer före inträdd konidiebildning (× 415). *b*. Äldre hyf med begynnande membranförslemning (× 745). *c*. Hyfgrenar av *Hormiscium*-typ (× 415). *d*. *Coniothecium*-lika cellkroppar (× 415). *e*. Palissadliknande konidiebildning från äldre hyf (× 1420). *f*. Hyf stadd i resorption med förtjockade, urglaslika tvärväggar (× 745). *g*. Konidier under knoppning samt äldre sådana med mörkfärgad membran, därav ett par tvåcelliga (× 415). *h*. Konidier, bildade inuti trakeider i tallved (× 1420). *a*—*g* ur täckglaskultur.

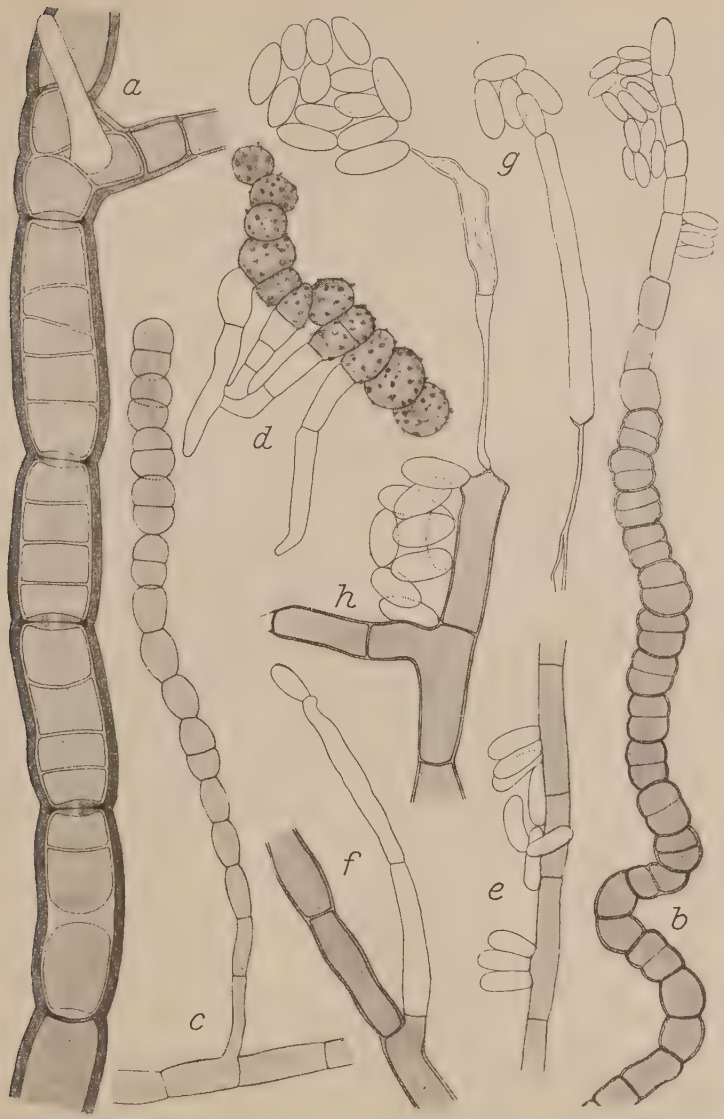


Fig. 39. *Hormonema dematioides*. Strain from pine-needles. *a*. Older hypha with intercalary cellular formation (× 1550). *b*. Younger non-ramified hypha of *Hormiscium* type, with conidial formation from the hyaline top-part (× 715). *c*. Hyphal branch of *Torula*-type (× 860). *d*. Older, *Hormiscium*-like hyphal portion with germinating cells (× 860). *e—h*. Hyphæ with conidial formation, of which *g* and *h* with resorption phenomena (× 1550). All pictures from cover-glass cultures.

Stam från tallbarr. *a*. Äldre hyf med interkalär cellbildning (× 1550). *b*. Yngre, ogrenad hyf av *Hormiscium*-typ med konidiebildning från den hyalina toppdelen (× 715). *c*. Hyfgren av *Torula*-typ (× 860), *d* äldre, *Hormiscium*-lik hyfdel med utgroende celler (× 860). *e—h*. Hyfer med konidiebildning, därav *g* och *h* med resorptionsfenomen (× 1550). Samtliga bilder från täckglaskultur.

grow rather thick and is usually covered with granular exudations. In older cultures its outer layer has become strongly mucose. The introduction to this change consists in the outer vagina dissolving (fig. 38 *b*) in the form of irregular umbos which finally burst, so that the adjacent hyphæ are imprisoned in a joint, olive-brown, gelatinous mass.

Quite a remarkable development of the transverse walls occurs in older hyphæ of longicellular type. These undergo a distinct secondary thickening, become lenticular and dark-brown (fig. 39 *a*). One always sees in the centre of the wall a circular, light spot, and in profile it is crossed by a light band which clearly indicates the occurrence of a pit. The same is also in its centre bisected by an extremely thin middle lamella. The secondary division which the long thick-walled cells undergo is also remarkable. They are divided into varying numbers of flat filial cells through thin, hyaline walls and thus greatly resemble the stages of *Hormiscium antiquum* which are illustrated by LINDAU (1906, fig. on p. 589). The purpose of this development is to renew the mycelium, because the filial cells germinate sooner or later into filaments, generally all simultaneously and occasionally in the same direction. Quiescent stages of another kind are developed in connection with secondary longitudinal walls in the hyphal cells. In this way there occur through partition on three levels at right angles to one another bodies of a *Sarcina*-nature and cellular aggregations more or less resembling *Coniothecium* (fig. 38 *d*) which through the dissolution of the adjoining cells may become quite isolated.

Of special interest are the resorption-phenomena which soon make their appearance in the mycelium. They concern not only the hyaline, longicellular, narrow and colourless hyphæ in the periphery of the colonies but also older hyphal complexes. Series of cells collapse and are emptied, while single ones, or a few in conjunction, are left behind in an undisturbed condition. Those cells appear at the beginning to be joined together by fine, hyaline filaments (the remnants of the destroyed cells), but are finally entirely isolated. Their continued development may afterwards follow rather different lines. Still more peculiar appears to be the dissolution of hyphæ which takes place in connection with the conidial formation. It looks as if the cells in this case were first emptied of their content and get their longitudinal walls greatly attenuated, whilst the transverse walls remain unchanged as thick, yellow-brown discs more or less like a watch-glass (fig. 38 *f*). But finally the filamentary remnants disappear entirely and the conidia become then quite isolated in the substratum (fig. 39 *h*). This resorption also supplies

the explanation to the long, ligamental agglomerations of conidia which appear in the cultures. They have originally developed round a hypha and follow closely the latter's sinuous course, which is also retained after the hypha itself has been entirely destroyed.

The conidial formation does not take place regularly. They conidia grow from the hyphæ practically anywhere, single or in groups (fig. 39 *b*, *e*, *h*), sometimes so densely that they give the impression of a regular palisade (fig. 38 *e;* fig. 40). Budding can also take place in the hyphal apices)fig. 39 *f*, *g*). As a rule the conidial formation seems to be faster on the younger hyphæ, but this does by no means prevent it from taking place on the older, thick-walled hyphæ (fig. 38 *e*). The full grown conidia

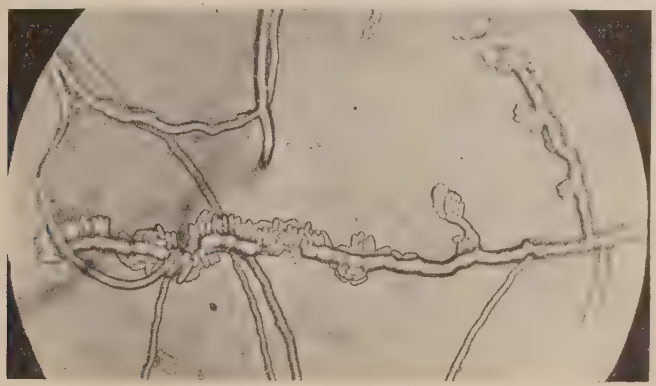


Photo by E. Melin.

Fig. 40. *Hormonema dematioides.* Palisade-like conidial formation from a brevicellular hypha in a cover-glass culture (× 340).
Palissadliknande konidiebildning från en kortcellig hyf i en täckglaskultur (× 340).

are fairly regularly ellipsoidal, between 6 and 11 μ long and 3,0—5,25 μ thick. After some time their oil contents are generally condensed into 2 large drops. The extremely thin walls may darken in time, or the conidia may even become bicellular (fig. 38 *g*) through the appearance of a partition wall.

Hormonema dematioides displays great variety of form in wood. Even the outer picture presents a rather varying aspect. On pine-wood sectors inoculated with conidia a vigorous, grey-green, finally darkly grey-brown air-mycelium appears occasionally and covers the entire tangential surface. The strain of the fungus which was isolated in the year 1923 has behaved in this manner. In other cases, when younger strains had been used in the inoculation-tests, no noticeable air-mycelium

has grown, and one got the idea that the results of the tetst would turn out negative. This was for instance the case with the strain isolated from pine-needles, which was inoculated on pine-wood one week after isolation. It was, however, discovered that the fungus had immediately penetrated deeply into the wood and discoloured the same just as intensely as in those tests where air-mycelium had developed. Nor is there any difference in the character of the blueing, inasmuch as the colour is dark-grey, shifting into olive-green, but it is not homogeneously spread but leaves radiating strips of wood on a cross-section more or less untouched. The development in spruce-wood proceeds slowly and the discoloration is mostly much less intense (cf. Plate II).

The mycelium grows remarkably strongly within the pine-wood. The rows of parenchyma cells in the pith-rays are isolated from each other and are contracted so strongly that one can often believe them to be completely destroyed. But the longitudinal walls remain as transparent sheaths around the radial series of hyphæ. The hyphæ are intensely brown coloured and even the very slender ones are everywhere covered with irregular, dark laminae. The thicker ones, about 10 μ, are pronouncedly brevicellular — the outline of the cells is almost quadratic — and as they lie closely packed, abnormally thick lateral branches with short, dentritically arranged, appendicatory eversions appear which are compressed into a kind of pseudoparenchyma. The same peculiar resorptive phenomena as have been observed in the agar-cultures are repeated here and occur even in the stouter hyphæ. Their previously thick and dark-brown longitudinal walls become attenuated so that only thin, light-brown films remain, the contents of the cells disappear, but the transverse walls remain to the last as thick, dark-brown plates shaped like a watch-glass.

In the stronger pith-rays, especially in the fusiform ones, the hyphæ sometimes grow rather sinuously and irregularly. They change into brevicellular catenations of *Hormiscium*-type and are compressed into compact masses. New divisions soon appear in the cells through longitudinal walls in two levels at right angles to one another, by which means complicated, *Sarcina*-like stages or pure *Coniothecium*-bodies originate. It is moreover obvious that a still more detailed fragmentation of the hyphæ can occur, for monocellular or bicellular, ellipsoidal brown bodies which appear to have been isolated from hyphæ are frequently found within the pith-rays, and especially within the protuberant membranes of the large angular pits. It is, however, extremely difficult to determine their origin with certainty on account of the remarkably profuse

conidial formation which proceeds within the wood. Large portions of the wider spring-tracheids, especially such terminal pieces as abut on the pith-rays, can be completely crowded with hyaline conidia of a greatly varying size and shape (fig. 38 *h*), and it is evident that they are here in a lively condition of budding. The cavity of the bordered pits are also frequently replete with conidia, whilst the tracheids are otherwise empty. They have sometimes been found to be intensely brown-coloured and now and then even bipartite. The similarity to the free cellular bodies which may be assumed to have originated through the fragmentation of the hyphæ is then considerable; the latter are, however, a trifle larger.

The hyphæ select the pits exclusively as a passage between the tracheids. The pits may occasionally be obstructed by short, irregular branches with a profuse, dark-brown membranous exudation. The single, fairly longicellular hyphæ in the tracheids have a quite sinuous course and their ramification is sparse. Here and there moniliform rows appear in them through the tumefaction of more or fewer cells in succession, and these moniliform series contrast sharply with the adjoining narrower portions of the hyphæ (fig. 41) through the thickness of the walls and the dark colour. These very characteristic stages agree so closely with the illustations of *Xenodochus ligniperda* given by WILLKOMM (1866, Pl. I, fig. 1, 3; Pl. II, fig. 8, 11, 14; Pl. IV, fig. 39, 44) and HARTIG (1878, l. XI, fig. 9) that one cannot easily doubt their identity. WILLKOMM wanted to make this fungus chiefly responsible for decay in both spruce and oak-trunks (cf. work cited, p. 67), but his deduction was, of course, due to insufficient experience. Fungi of this type are no rot-fungi. *Xenodochus* has in the cases investigated been a perfectly secondary feature and has grown in previously decayed wood. HARTIG judges the fungus correctly, as he does not connect

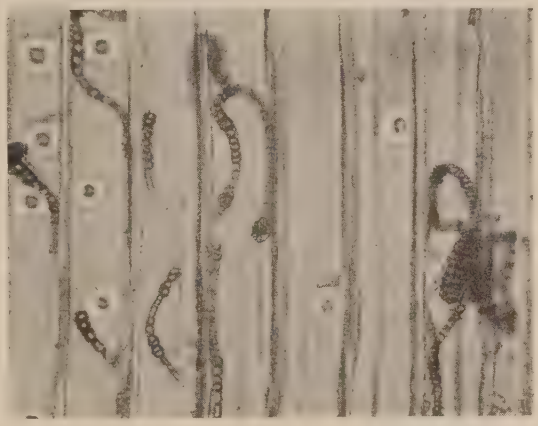


Photo by T. Lagerberg.

Fig. 41. *Hormonema dematioides.* Hyphæ with moniliform rows of cells (= *Xenodochus ligniperda* Hartig) and *Coniothecium*-like groups of cells. (× 115). Pure cultu reon pinewood.
Hyfer med pärlbandslika cellräckor (= *Xenodochus ligniperda* Hartig) och *Coniothecium*-likt cellförband. (× 115). Renkultur på tallved.

with the origin of the rot, which in the case investigated was *Armillaria mellea*.

The short rows of spherical cells are able through subdivision to develop into elongated bodies which are released through the resorp tion of adjacent hyphal parts. It is not as yet quite clear of what importance these cellular bodies are in the biology of the fungus. One finds, however, frequently that their cells germinate into fine, hyaline and longicellular hyphæ (fig. 42). It should finally be added that the tracheids often contain crowds of brown, bicellular bodies which through their size (11—12 × 7 μ) correspond to a secondary bipartite cell from a moniliform part of a hypha. Even in these isolated bodies new walls appear, and the result of these are small, irregular clusters of *Sarcina*-type.

Photo by T. Lagerberg.

Fig. 42. *Hormonema dematioides*. Brevicellular portion of hypha isolated through resorption, partly of *Sarcina*-like development, whose cells grow into narrow, sub-hyaline hyphæ (× 115). Pure culture on pine-wood.

Genom resorption isolerat, kortcelligt hyfparti, delvis av *Sarcina*-lik utbildning, vars celler utväxa i smala, subhyalina hyfer. (× 115). Renkultur på tallved.

On the tangential surface of the inoculated sectors of wood the mycelium appears through the cross-sectioned pith-rays, and after a cultivation period of 14 days this therefore looks dirty and punctated. This appearance is due to the dark-coloured, *Coniothecium*-like cellular bodies which fill the orifices of the pith-rays and parts of the vertical resin-ducts bipartite in the section. A remarkably profuse conidial formation takes place on the surface from these cellular bodies and also from the lax and ocularly hardly discernible retiform hyphæ. The conidia bud so profusely that it is sometimes impossible to see anything of the hypha from which they originate. Many of the figures wich may be seen here remind one very much of the one presented by KRESS and his collaborators (1925, Pl. XX, fig. 2) of an unidentified form of *Dematiaceæ* which they had discovered to be very common in wood-pulp, and which imparted to the latter a grey tint. Maybe also this American fungus is nothing but *Hormonema dematioides*.

On the tangential surfaces of the pine-sectors there appeared also in the course of time dense, flat, sooty-black crusts up to 2 mm. wide. These proved under the microscope to consist of nothing but spherical cells in a more

or less distinct *Sarcina*-packing. Their similarity to a crust of sooty mould was striking.

The manner of growth of *Hormonema dematioides* in spruce-wood has not been subjected to a detailed investigation. It behaves to this substratum in the same capricious manner as many other blueing fungi. In certain tests it has been unable to cause any discoloration, or such could only be feebly traced (cf. Plate II), in others again the blueing was perfectly distinct, although in respect of intensity and extent much fainter than in pinewood.

Hormonema LAGERBERG et MELIN nov. gen.

Hyphis effusis, initio e cellulis longis compositis, mox catenulatis et e cellulis plus minus cuboideis vel globoideis formatis, opacis vel hyalinis. Conidiis hyalinis, continuis, ellipsoideis, e hypharum lateribus vel apicibus singulatim oriundis.

H. dematioides LAGERBERG et MELIN n. sp.

Hyphis olivaceo-nigricantibus, irregulariter rugulosis, e parte catenas moniliformes vel coniothecia formantibus, vel ramulos omnino toruloideos gerentibus, lignum præcipue *Pini silvestris* facile penetrantibus et colorem in griseo-olivaceum mutantibus. Conidiis hyalinis, sensim interdum olivascentibus pro parte bicellularibus, 6—11 × 3—5,25 μ. *Dematio pullulanti* Neger species valde affinis.

Trichosporium tingens LAGERBERG et MELIN n. sp.

The only locality hitherto known for this fungus is:

1. Dalecarlia, Garpenberg, 26. 11. 1923. From pine-timber belonging to the storage tests. The fungus grew absolutely pure from the sample selected.

A fairly vigorous, finely floccose air-mycelium develops on malt-agar, and this is at first light-grey in colour (fig. 43), but gradually changes from greyish-brown into sooty-brown. The under-side of the colonies is then black-green or almost black. Rate of growth 4,5 (cf. note p. 164). No specific odour is developed. Conidial formation commences gradually, and on the sectors there appear fairly numerous, woolly pulvilli sprinkled all over with light brown conidia, (fig. 44) and fully 1 mm. in diameter. These pulvilli are developed still more profusely on timber. They are actually the best characteristic of the fungus.

The conditions for the development of the mycelium have been closely studied in cover-glass cultures. The hyphæ assume here very soon a dark colour. Very noticeable ramification appears after only a week's growth, and this seems to be specific for this fungus. The cells are as a rule long and narrow, and their membranes glossy. Here and there

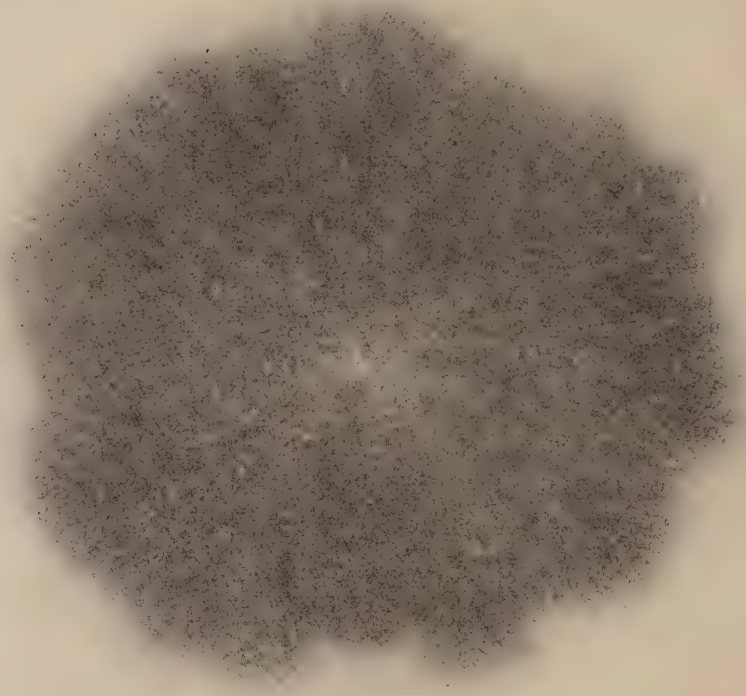


Photo by E. Melin.

Fig. 43. *Trichosporium tingens.* Pure culture on malt-agar. The hyaline hyphæ in the marginal zones are not discernible in the picture. (× 1,3).
Renkultur på maltagar. De hyalina hyferna i kantzonen framträda ej på bilden. (× 1,3).

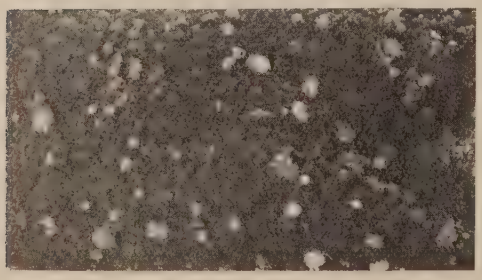


Photo by E. Melin.

Fig. 44. *Trichosporium tingens.* Detail from pure culture on malt-agar. Lanate conidial collections in the air-mycelium (× 3).
Detalj från renkultur på maltagar. I luftmycelet flockiga konidiesamlingar (× 3).

bushy, but very irregularly ramified systems of hyphæ grow laterally from the hyphæ (fig. 45 *a*), containing cellular forms which on account of their protuberances assume more or less the appearance of elk-antlers. The terminal ramifications in these complexes are perfectly hyaline. Another frequently recurring form of development of the hyphæ is illustrated in fig. 45 *b*. We see here how the cells in some of the shorter

branches swell out and thus form chains which more or less resemble pearl necklaces. In view of such a picture one should, maybe, be inclined to think of a commencing conidial formation, but these brevicellular hyphæ have nothing to do with this. They always contain, however, large quantities of oil and should properly be put down as hypertrophies.

There have been considerable difficulties in determining with any certainty the method of the conidial formation. As the conidia are discharged on to the budding apices of branches, the latter are generally concealed and are therefore not accessible for direct examination under the microscope. It is absolutely useless to examine material in water, as it undergoes such a complete change that one cannot form any idea of the nature of the conidial clusters or the method of the conidial formation. From LINDAU's treatment (1907, p. 645) of the genus

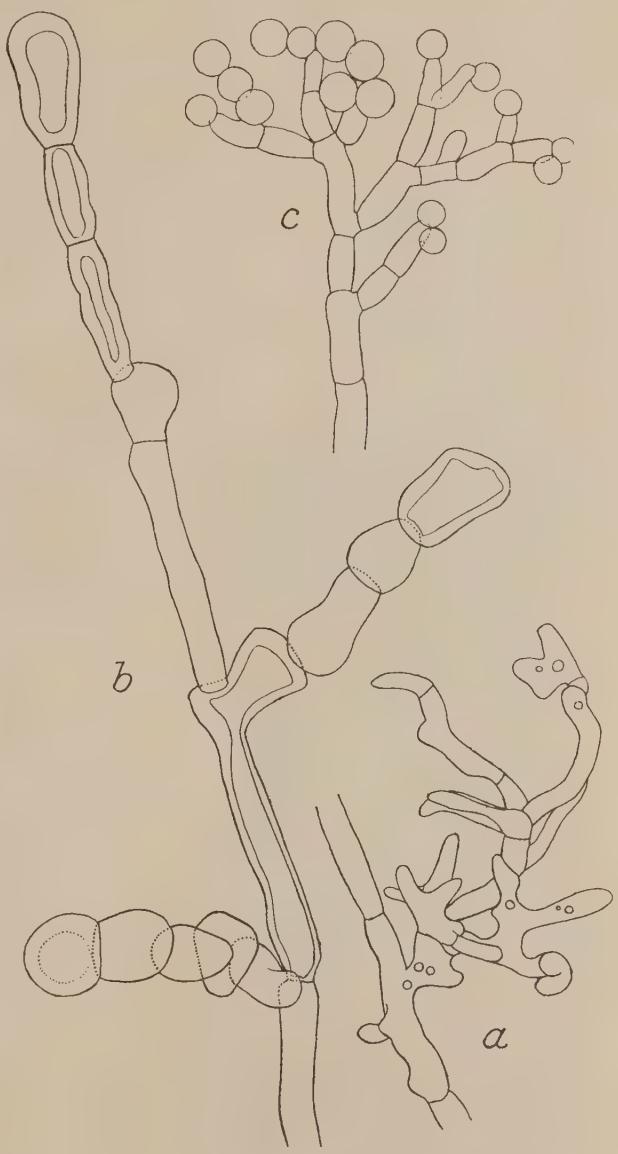


Fig. 45. *Trichosporium tingens.* *a*. Hypha with lateral, dendritic system of ramification (× 1000). *b*. Form of growth of hypha in cover-glass culture — several cells with large quantities of oil (× 1000). *c*. Portion of conidial cluster (× 560).

a. Hyf med lateralt, dendritiskt grensystem (× 1000). *b*. Växtform av hyf i täckglaskultur — flera celler med stora oljemassor (× 1000). *c*. Del av konidieställning (× 560).

Trichosporium it is also obvious that the conidial formation is the weak point; it is, in fact, unknown in most of the species which have been included in this undoubtedly very heterogeneous genus. It has, however, been stated as a characteristic of the genus that the unicellular, globular or oval conidia are formed on the apex or on the side of hyphæ or their terminal ramifications; consequently no moniliform rows occur. Nevertheless it is by no means easy to determine exactly if such bonds are really absent, inasmuch as the conidia frequently occasionally combine in this manner after they have been isolated. We have in our species seen rows of a few conidia issuing from those which were still firmly attached to the hyphæ, but we are rather inclined to believe that such a chain is of secondary origin. Our cover-glass cultures have, however, proved sufficiently that conidia are developed from fairly short, but greatly and irregularly ramified systems of hyphæ; the one illustrated in fig. 45 *c* is only a small fragment of such a one. The conidia are here constricted not only at the apices of the branches but also sub-terminally, and it also looks as if a lateral conidial formation occurred. The conidia are unicellular, comparatively thick-walled and absolutely spherical. Their diameter varies between 10,5 and 6 μ. The type remains unchanged independently of the substratum. The membrane is hyaline and quite smooth, but gradually assumes a somewhat brownish tint which is discernible by the naked eye as a light-brown colour of the conidial agglomerations. Budding does not seem to be unusual in tube-cultures.

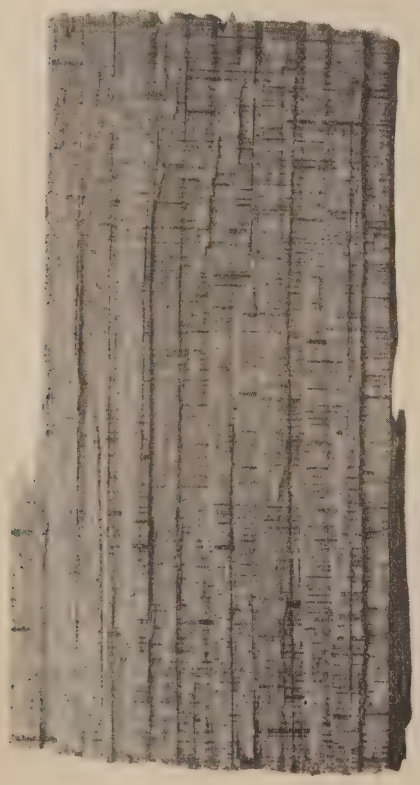


Photo by T. Lagerberg.

Fig. 46. *Trichosporium tingens.* Radial section of pine-wood, with pith-rays darkly coloured by hyphæ (× 1,5).

Radiärt längdsnitt av tallved med av hyfer mörkfärgade märgstrålar (× 1,5).

As shown by Plate II, *Trichosporium tingens* is one of the more active blueing fungi. The pith-rays appear on the radial section in the form of blackened ribbons (fig. 46), and the vertical resin-ducts as very fine black lines. The cross-section

exhibits a more blue-black tint. The hyphæ are in the pith-rays concentrated to the parenchyma cells which are constricted like an hour-glass. Their membranes assume, in so far as the pith-pays are penetrated by the hyphæ, an intense olive-brown colour, and the same colour can also be detected locally on the membranes of the bordered pits, both in the tracheids (close to the pith-rays) and in the marginal cells. The parenchyma of the pith-rays contains not only fairly straight and up to 10 μ thick, dark-brown hyphæ, but also many which are more sinuous, lighter in colour, and only about half as thick. On the outside of the membranes there occur more or less profuse exudations in the form of tiny, black-brown, hemispherically shaped lumps which with Sudan III assume a bright red colour and are consequently probably composed of some fatty substance. In the horizontal resin-ducts coarse, horizontal hyphæ are so plentifully developed that the pith-rays appear quite black not only to the naked eye but also under the microscope. A still more vigorous growth is developed in those hyphæ which occur in the vertical resin-ducts. As will be seen from figure 47, the excretions from the membranes have become so prolific that they have coagulated into thick crusts. Here dendritically ramified hyphæ also appear, and these are embedded in a common, dark-brown secretion.

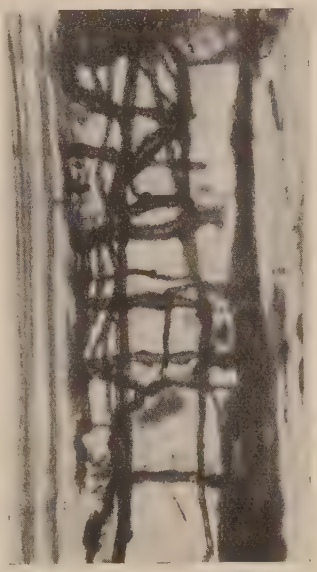


Photo by T. Lagerberg.

Fig. 47. *Trichosporium tingens.* Vertical resin-duct in pine-wood, with hyphæ, possessing thick, dark-coloured mucus vaginæ. Vertikal hartsgång i tallved med hyfer, som ha tjocka, mörkfärgade slemskidor (× 115).

Longitudinal hyphæ are very common in the tracheids; not only coarse and dark-brown ones up to 15 μ thick, but also narrower (2—4 μ), lighter, regularly sinuous and dendritically branched ones. On the latter there always occur thin hemispherical membraneous protuberances. The coarser hyphæ are often very nodose on account of local membraneous protuberances, which sometimes develop into short, thick branches projecting at right angles. The latter remain enclosed in the tracheids. Exceedingly short, thin branches, almost spiky in appearance, frequently grow on these protuberances. There occur also here and there systems of ramification like elk-antlers and of quite the same type as those that have been observed in agar-cultures. A large number of the coarser hyphæ

were apparently dead, as one could see that they had been pierced and partially filled with finer hyphæ. No direct perforations of the tracheid-walls occur. On the other hand, the bordered pits are penetrated all the more frequently, and the penetrating hypha is inclined to acquire a spherical swelling in the cavity of the pit.

The above account of the growth and appearance of the mycelium on pine-wood is based on a research made with the original material. The fungus developed in exactly the same manner on the same substratum in pure cultures.

Plate II shows that *Trichosporium tingens* produces distinct blueing also on spruce-wood, although generally on a smaller scale. Microscopic examination of similar material showed that the hyphæ develop in much the same way as in pine. In the pith-rays they were, however, much narrower and the membraneous laminæ were entirely absent. The hyphæ of the tracheids were brown and thin-walled, up to 15 μ thick, and had locally developed dendritic systems of ramification as mentioned above.

None of the *Trichosporium* species that are described at present can be identified with our species. We must, of course, in this connection entirely leave out of consideration those whose diagnoses are so incomplete that a comparison is out of the question on that account. From pine-wood are described *Trichosporium fuscum* Link 1809, with brown, ellipsoidal conidia (understood as belonging to *Rosellinia aquila*), further *Tr. aterrimum* Corda 1837, which is said to have brown, semi-transparent, ellipsoidal conidia (no measurement) and *Tr. fuscescens* Cooke 1884 (from California) with conidia of 10—12 × 7 μ, without specified colour. None of these can on account of the conidial formation have anything in common with the species here concerned, nor can they on the other hand be connected with any of the species whose conidia are alleged to be spherical, inasmuch as other characteristics are opposed to this. We have therefore been compelled to increase the already large genus *Trichosporium* with a further species, and to give a summary diagnosis of the same.

Trichosporium tingens LAGERBERG et MELIN n. sp.

Mycelio fuligineo, lignum præcipue *Pini silvestris* facile penetrante et colorem ejusdem in griseo-atrum mutante. Hyphis e cellulis longis compositis, tuberculis minutis hemisphæroideis opacis sparsis præditis, vel vagina continua mucosa olivaceo-fusca obvolutis. Hyphis fertilibus erectis, ramosis, dense aggregatis, acervulos circ. 1 mm diam. formantibus. Conidiis apicalibus, subterminalibus vel lateralibus e ramulis ultimis orientibus, sphæroideis, hyalinis, sensim paulo fuscescentibus, levibus, 6—10,5 μ diam.

Hormodendrum cladosporioides (Fres.) Sacc.

This form, which is very common on timber, has been isolated from the following localities:

1. Dalecarlia, Garpenberg, 29. 7. 1923. From spring-felled pine, taken from storage tests together with *Cadophora fastigiata* and *Stereum sanguinolentum*.
2. Västmanland, Bjurfors, 4. 8. 1924. From the decorticated ends of a spruce-log which had been felled on $^{25}/_{7}$ in the same summer, and which in a week's time became coated with a dense vegetation of the fungus.
3. Ångermanland, Svanö, Aug. 1925. From sawn spruce-timber, together with *Cadophora fastigiata* and *Hormonema dematioides*.
4. Ångermanland, Kramfors, Sept. 1925. From sawn pine-timber: partly with *Cadophora fastigiata* and partly with both *C. fastigiata* and *Penicillium biforme*.
5. Ångermanland, Marieberg, Aug. 1925. From sawn spruce-timber.
6. Gästrikland, Skutskär, Sept. 1925. From sawn pine and spruce-timber.
7. Gästrikland, Bomhus, Sept. 1925. From sawn pine-timber.
8. Värmland, Skoghall Works, Nov. 1925. From sawn spruce-timber: alone; together with *Discula pinicola* var. *mammosa*; together with *Cadophora*, *Hormonema dematioides* and *Penicillium biforme*.
9. Dalecarlia, Garpenberg, Dec. 1926. From pine-logs felled in Sept. 1926.
10. On various occasions in the Mycological Laboraty of the College of Forestry from both pine and spruce-timber.

It is obviously this fungus which at an earlier date has been investigated by HEDGCOCK (work cited p. 99) in North America and by MÜNCH (1907, p. 571) in Germany. The last-mentioned author describes it as a *Cladosporium* and considers it to be identical with the species treated by HEDGCOCK under the name of *Hormodendron cladosporioides* (Fres.) Sacc. The latter has namely by systematists been considered as being only a form of the cosmopolitan, extremely common »*Cladosporium herbarum* LINK». It is not our intention to analyse this systematical question here. If we continue to call our fungus *Hormodendrum cladosporioides*, it is because the conidial type which has made its appearance in our pure cultures, both on malt-agar and wood, relegates it to the section *Phæosporæ* of the *Dematiaceæ*, whilst the *Cladosporium* species through their bicellular conidia come under the second section *Phæodidymæ*. Exactly the same reasons have induced HEDGCOCK to his nomenclature. He points out that if the cells of the system of ramification of the conidial clusters — which are also easily isolated — are looked upon as conidia, one must admit that such with two cells can occur; the classification of the fungus under the genus *Cladosporium* is under such circumstances explicable.

In pure cultures on malt-agar *Hormodendrum cladosporioides* develops

compact, woolly colonies (fig. 48), at first greyish-brown, finally greenish grey-brown to brown in colour; the under-side seems to be olive-green or black. HEDGCOCK's definition of colour is as follows: the younger portions of the mycelium assume a yellowish-green tint, which quickly changes to olive and finally almost black. MÜNCH discovered that the mycelium and the conidia began to darken in two or three days, and the latter assumed a dark olive-green tint. The rate of growth of the mycelium is only 1 (cf. note p. 164), but in spite of this conidial development commences very soon and is extremely profuse. The conidia grow as terminal ramifications of very composite, racemose systems of hyphæ in which a more or less distinct dichotomy can be traced (fig. 49 *a*). They originate in short, frequently ramified chains, whose proximal cells are fairly large and rather elongated; the distal cells, on the other hand, which have been produced by the budding of the former, are shorter and smaller. The conidial formation thus takes place exclusively through terminal budding, not by intercalary cell-division. The conidia are monocellular, more or less regularly ellipsoidal and provided with a smooth, olive-green membrane. They are easily isolated, either separatedly or a few together (fig. 49 *b*). The size varies according to our measurements between 3,7—9,3 × 2,8—5 μ. After separation they bud profusely.

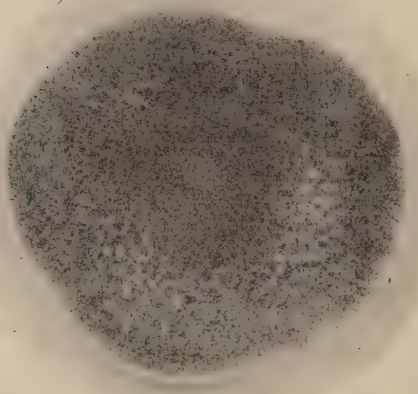


Photo by E. Melin.

Fig. 48 *Hormodendrum cladosporioides*. Pure culture on malt-agar (× 1,4).
Renkultur på maltagar (× 1,4).

As mentioned above it is also usual for the more basal portions of the system of ramification to fall to pieces. The cells isolated from these fragments may many a time appear to be conidia, and in reality they also function as such, but the transversal walls which occur point to another origin (fig. 49 *c*). This is, moreover, evident from the peg-like excrescences at their ends which mark the place where the branches or rows of conidia have been attached.

Hormodendrum cladosporioides is probably more responsible than any other species for the so-called surface-blueing of coniferous timber. One might perhaps from this gain the impression that the practical rôle of

this fungus is not very important. When MÜNCH (1907, p. 572) attempted to infect newly felled timber with this fungus he obtained, as previously mentioned, no positive result and was thus induced to consider it of no practical importance as a blueing fungus. HEDGCOCK's attempts to infect the pine and also some kinds of broadleaved trees only resulted

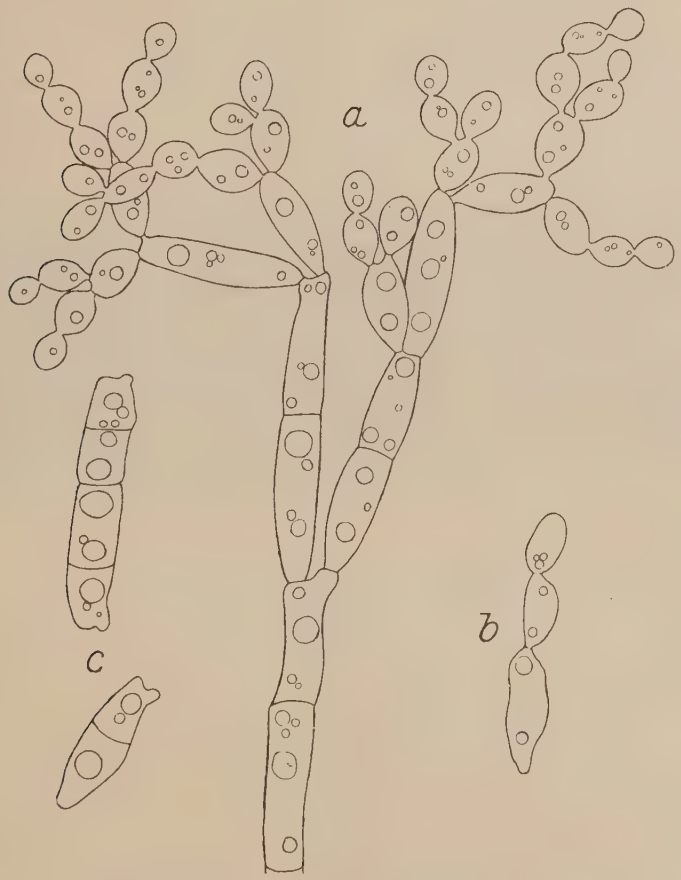


Fig. 49. *Hormodendrum cladosporioides*. *a*. Conidial cluster. *b*. Isolated conidia in conjunction. *c*. Isolated cells from the system of ramification. (× 1125).

a. Konidieställning. *b*. Isolerade konidier i förband. *c*. Isolerade celler ur grensystemet. (× 1125).

in a superficial dark staining. In wood of *Liquidambar styraciflua* the fungus, however, penetrated deeply. Our tests have fully proved that *Hormodendrum cladosporioides* is also a really important blueing fungus where coniferous wood is concerned. Under favourable conditions it may

penetrate deeply into both pine and spruce-wood and produce an intensive, almost black, discoloration (cf. Plate I).

On timber the fungus develops a vigorous, olive-green mycelium which grows better on pine than on spruce. The following observations are given from an infected piece of spring-felled pine. The parenchyma of the pith-rays was crowded with black-brown hyphæ with membraneous laminæ of the same colour. In the fusiform pith-rays the mycelium displayed an extremely luxuriant development. Here there occurred straight rows of hyphæ, with a thickness of as much as 22 μ and with cells that were shorter than this measurement, and also proper hanks of only 4 μ thick hyphæ, and even these with a brown membraneous

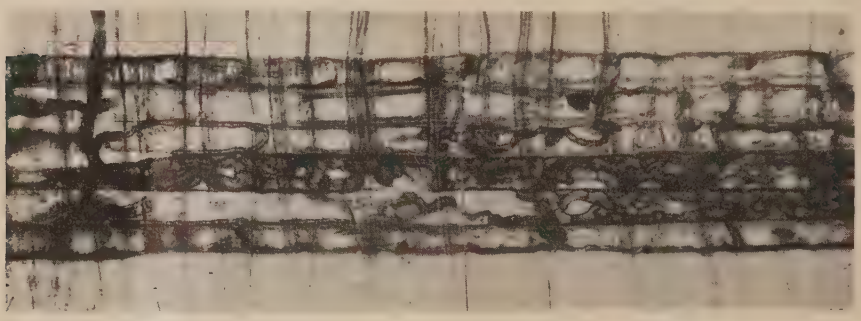


Photo by T. Lagerberg.

Fig. 50. *Hormodendrum cladosporioides*. Pith-ray with pseudoparenchymatous crowd of hyphæ in 2 out of the 6 rows of parenchyma-cells (× 115). Pure culture on pine-wood.

Märgstråle med pseudoparenkymlika hyfanhopningar i 2 av de 6 parenkymcellraderna (× 115). Renkultur på tallved.

exudation. Here and there the parenchyma cells were entirely crowded with thick, strongly lobed or short-branched hyphæ, so closely interwoven with one another as to remind one of a pseudoparenchyma (fig. 50); these branches were not separated by walls. The fungus grows almost as vigorously in the tracheids. One finds here not only narrow and longicellular but also thick and brevicellular hyphæ, the latter reminding one of those characteristic of *Hormonema dematioides*, although intercalary cell-divisions do not seem to occur. Granular exudations on the membranes are nevertheless very common. On some narrow, longicellular hyphæ there occurred narrowly claviform swellings below the transversal walls where the membraneous lamina were thicker. Direct perforation of the tracheid walls does not occur, but on the other hand the bordered pits are penetrated to a far greater extent. The peculiarity already mentioned in respect of one or two blueing fungi to the effect

that the bordered pits seem to exercise a localising influence upon the ramification of the vertical hyphæ recurs in *Hormodendrum cladosporioides*. The cavity of the pits is often entirely crowded with thin, sinuous hyphæ, but in other cases these are replaced by short, irregularly lobed branches which are more or less completely covered with thick, black-brown membraneous laminæ.

The tracheid hyphæ often form a kind of quiescent stages. A case has thus been noted where a sharply detached row of 7 cells, with a thickness of 8,9 μ, had developed in a hypha which was otherwise only 4 μ thick. MÜNCH (1907, p. 572 fig. 27 d) mentions the occurence of such stages in older agar-cultures.

The fungus has also been investigated as to its behaviour in winter-felled pine-timber. Like other blueing fungi it develops more vigorously in such wood. Certain differences in the form of growth of the hyphæ were clearly noticeable here. Both in the pith-rays and in the resin-ducts the latter were remarkably straight, without any indication of pseudoparenchymatous development. The quantity of oil contained in the hyphæ of all sizes was particularly striking. Of the greatest interest to us is, however, the circumstance that the mycelium in the wider spring tracheids had developed conidial clusters whose branches on account of the limited space were, however, very closely packed together. The conidia were constricted in exactly the same manner as on the air-mycelium and had afterwards budded so very profusely that the tracheids were crammed for quite long distances by a lot of small, olive-brown cells just like a cartridge is filled with shot. It is possible that similar collections also develop through fragmentation of vertical, brevicellular hyphæ and the budding which subsequently takes place in the isolated cells. These compact masses of conidia were very common in the tracheids of the infected piece of wood, and it was obvious that the intensely dark staining of the specimen of wood was principally due to an internal conidial growth.

In order to enable *Hormodendrum cladosporioides* to penetrate spruce-wood quite special conditions are obviously necessary. From Plate I it will be seen that the fungus has only been able to produce a very limited and rather faint discoloration in the two outer rings of the wood, and this only in the actually infected spot. Nor did it penetrate at all into spring-felled spruce but had rather developed superficially on the logs; winter-felled spruce-timber seems to be more favourable also for this fungus. If we follow the development of the hyphæ in such faintly blued spruce-timber, we find them only in the outermost rings of the wood, and especially the ends of the pith-rays are distinctly brown in

colour. Further in the colouring as well as the thickness of the hyphæ diminishes rapidly; the last mycelium-runners are very slender and perfectly hyaline.

Hormodendrum microsporum LAGERBERG et MELIN n. sp.

This fungus has only been found on one occasion:

1. Västmanland, Bjurfors State Forest, 9. 8. 1924. From blued wood in a live spruce-trunk which had been felled.

This fungus does probably not play any important part as a blueing fungus. It was, however, found under rather peculiar circumstances, and we have therefore considered an account of our investigations to be entitled to a place in this paper.

Photo by T. Lagerberg.

Fig. 51. *Hormodendrum microsporum*. Heart of spruce with vertical and transversal, wall-piercing hyphæ (× 115).
Kärnved av gran med vertikala och transversala, väggperforerande hyfer (× 115).

Some spruce-trees broken by snow were felled during the summer term of 1924 for the purpose of demonstrating top-rot to the students of the Forestry Courses. In one of these tree-trunks, which was about 190 years old and extremely backward in growth — the soil was shallow and the solid rock cropped out everywhere — there was discovered on the otherwise quite healthy stump on the cut made by the saw, a blueish-grey, strictly limited spot, about 2 × 3 cm. in size and situated only 2 cm. from the pith, i. e. entirely within the heart. This discoloured streak could be traced upwards to about 30 cm. above the level of the ground, where it terminated in a fine point. The interesting part of this very distinct blueing is on the one hand the fact that it occurred in the heart; and on the other that the blueing had been localised to the interior of the stump of a sound tree (apart from a very slight top-rot). In this case the blueing probably originated in the ground, i. e. a raw humus fungus made its way into the stump through some crack or a dead root, and penetrated further up through the heart, although the latter must have been pretty poor from a nutritive point of view. The fungus was obtained direct in pure culture from material saved, and one could therefore be certain that the mycelium in the tim-

ber was quite uniform. The original material could therefore be used direct for investigating the conditions of growth of the fungus.

It was at once obvious from the microscopic picture that the hyphæ grew principally through the tracheids and were very little attracted by the pith-rays (fig. 51), quite naturally enough as the parenchyma in the heart cannot be particularly attractive on account of its vacuousness. In several of the stronger pith-rays the hyphæ were en-

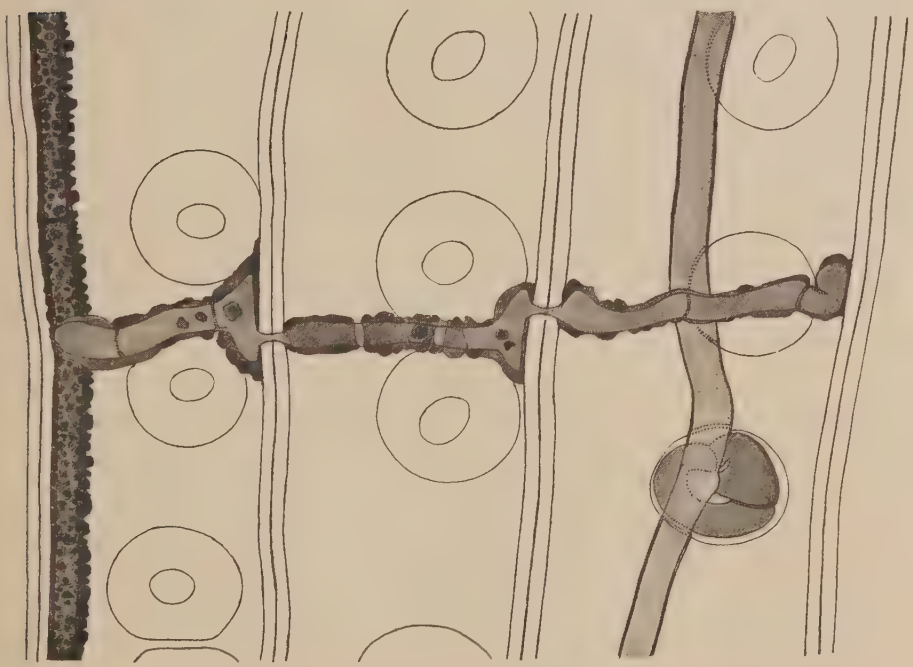


Fig. 52. *Hormodendrum microsporum.* Wall-piercing branch of hypha with adpressoria. Spruce-timber. (× 1070).
Väggperforerande hyfgren med adpressorier. Granved. (× 1070).

tirely absent, but where they did occur they grew almost as much in the marginal as in the parenchyma cells. The tracheidal hyphæ were straight and quite little ramified, on an average about 4 μ thick; the membrane of the older ones was dark olive-brown and coarse-grained by an almost black exudation (cf. fig. 52). Ramification occurred chiefly at right angles and the branches were characterized by an intense power of perforation. The slides were teeming with perforations in the tracheid walls; one and the same hypha could, without changing its direction, pass through the tangential walls in a whole row of tracheids; as many

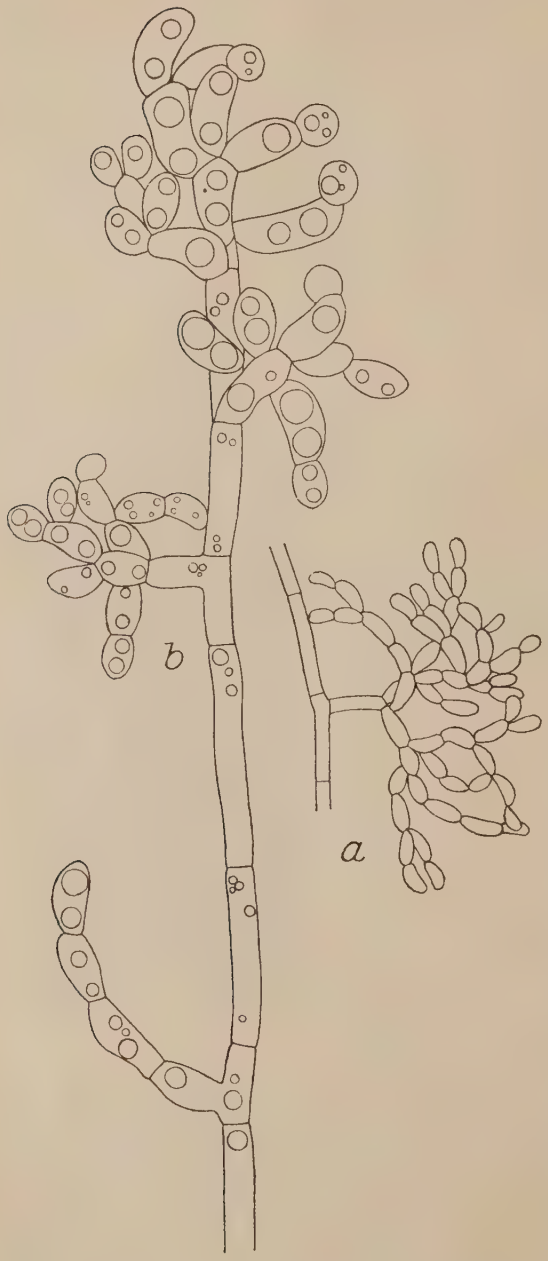


Fig. 53. *Hormodendrum microsporum*. *a*. Hypha with lateral conidial cluster (× 1065). *b*. Conidial formation (× 1930).

a. Hyf med lateral konidieställning (× 1065). *b*. Konidiebildning (× 1930).

as 14 having been observed. Sometimes the hyphæ seem, however, for some reason or other, to have difficulty in finding their way out of the tracheids, which are then more or less crowded with their hanks. The perforating hyphæ are secondarily able to increase their thickness and to deposit a very thick membranous exudation in the shape of nodules or fairly large laminæ. The adpressoria are pedalshaped and often remarkably strong (fig. 52). It also happens that the pedalshaped portion is prolonged for some distance along the tracheid-wall, and that this portion is separated by a wall. In this case the perforations may be produced by both cells of the adpressoria. The elongation of the foot may also be developed in a hypha which continues straight along the tracheid wall.

When two vertical hyphæ grow in the same tracheid, their crossbranches often establish ladder-like anastomoses. The bordered pits are not exploited to any great extent by the hyphæ in their progress; there are, of course, penetrations at these points, but just as often examples occur where

the branch has been shut in by the cavity of the pit and fills the latter more or less completely (fig. 52).

There were no hyphæ in the vertical resin-ducts which were completely obstructed by the enlarged but empty secretory cells.

The fungus grows slowly and at first principally submersed in pure cultures on malt-agar. The air-mycelium developed grows thin and sparse, and is light-grey in colour. Otherwise the colonies are dark olive-green, finally turning almost black. The hyphæ show a decided tendency to form threads; brevicellular portions have never been observed. The fungus grew sterile for a long time, and it was not until the substratum was acidified (by the addition of 0,03 % of lactic acid) that it could be induced to form conidia. The latter develop in profuse clusters, supported by longer or shorter hyphal branches which grow at right angles to the substratum hyphæ (fig. 53 *a*). They are dissolved into a system of generally dichotomously ramified chains of conidia (fig. 53 *a*), which are built up by terminal budding. All cells in these chains are alike, the proximal ones somewhat larger, though. They are easy isolated from one another in the slides — often a few together — and for this reason it is not only the cells which should be looked upon as conidia. In form they are usually slightly oblique and more or less fabaceous, the walls thin, colourless or somewhat yellowish. Amongst the contents one or two round, globular drops of oil are conspicuous (fig. 53 *b*); in the latter case the conidia may, at a hasty glance, appear to be bicellular. They are insignificant in size; the length varies between 3,7 and 5,6 μ, and the width is about 2 μ.

It may seem difficult to allocate to this fungus a place in the system. There are certain difficulties connected with the contrasts between the very darkcoloured mycelium and the hyaline conidia. It is, however, obvious that the fungus belongs to the *Dematiaccæ*, and its general organization relegates it to the sub-division *Haplographiæ*. *Hormodendrum* seems to be the only one of the genera referred to this which can be taken into consideration. Although the conidia according to the diagnosis of this genus should be olive-green or brown, LINDAU (1907, p. 702) has nevertheless transferred to it *Hormiactella obesa* described by VON HÖHNEL, in spite of this species having hyaline or sub-hyaline conidia; the classification of these forms of fungi is, of course, many a time arbitrary. We therefore identify our fungus as a *Hormodendrum* whose principal characteristic is the small hyaline conidia.

Hormodendrum microsporum LAGERBERG et MELIN n. sp.

Hyphis sterilibus repentibus e cellulis longis compositis, circ. 4 μ crassis, rugulosis, opace olivaceis. Hyphis fertilibus erectis, subhyalinis, levibus, sursum

ramulos sæpe furcatos, effuse aggregatos gerentibus, ramulis ultimis catenas conidiorum formantibus. Conidiis hyalinis, continuis, leviter curvatis, plerumque biguttulatis, 3,7—5,6 × 2 μ.

Hab. in ligno *Piceæ excelsæ*.

Leptographium Lundbergii LAGERBERG et MELIN nov. gen. et sp.

This form of fungus has hitherto been obtained by us only from a single locality:

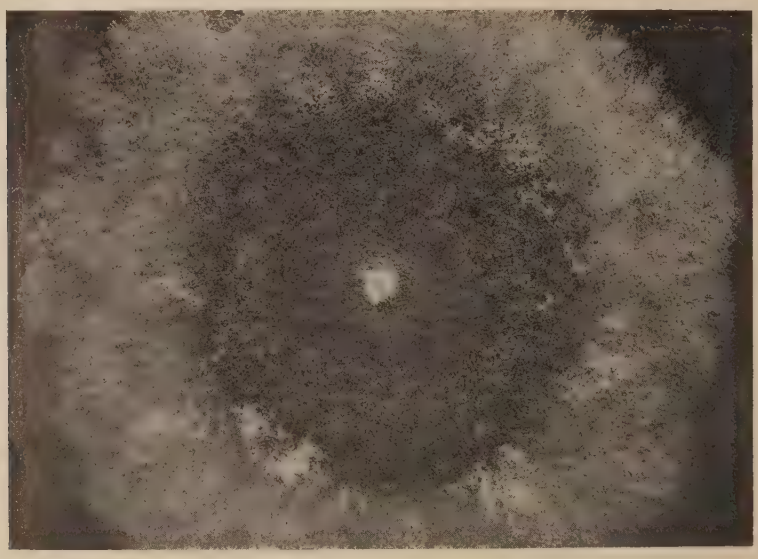


Photo by E. Melin.

Fig. 54. *Leptographium Lundbergii*. Pure culture on malt-agar. Nat. size. Renkultur på maltagar. Nat. storl.

1. Västmanland, Bjurfors State Forest 9. 8. 1924. Wind-felled, intensely blued pine-trunk, whose spotwise exposed wood-surface was densely covered with *Ceratostomella Pini*.

In culture on malt-agar the fungus develops a fairly sparse, filament-like air-mycelium which is at first whitish in colour but in time turns into a dark-grey to dark-brown shade (fig. 54). The under-side of the colonies turns green-black or almost black. Development is rapid, the rate of growth amounting to 10 (cf. note p. 164), i. e. the same as characterizes *Endoconidiophora cærulescens*. The mycelium gives off a smell which reminds one of sour wort. Conidial formation soon takes place; the conidia accumulate in white, finally honey-coloured, masses on the systems of budding hyphæ, and are there caught up in a spherical drop of

fluid. A plate-culture will therefore present great similarities to a *Graphium* vegetation, which is also the reason for our choice in the selection of the generic name. As is the case with *Ceratostomella Piceæ*, it often happens that continuous drops of water amalgamate into larger ones which then generally lose their spherical shape (fig. 55).

As difficulties were encountered in investigating the method of the conidial formation on the material which could be obtained from the

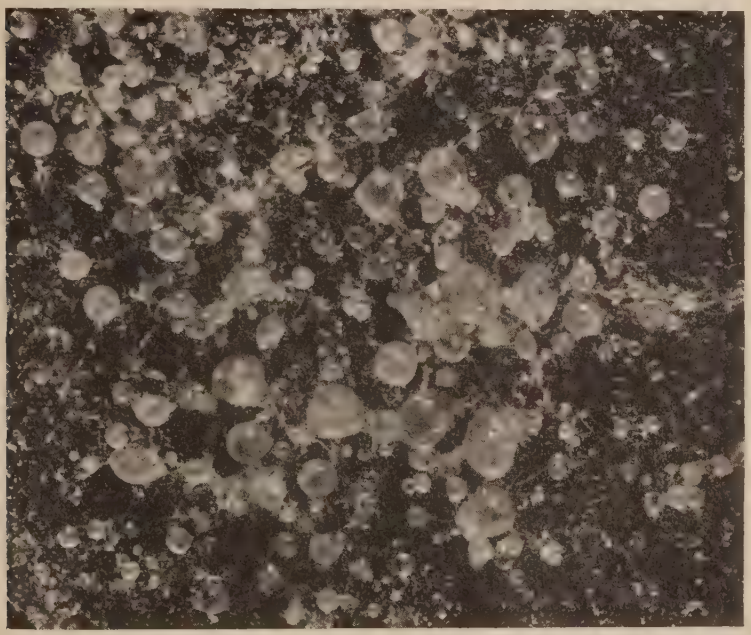


Photo by T. Lagerberg.

Fig. 55. *Leptographium Lundbergii*. Conidial clusters with drops of water. Detail from pure culture on malt-agar. (× 12).
Konidieställningar med vattenkulor. Detalj från renkultur på maltagar. (× 12).

cultures on wood or in Petri dishes, it was necessary to arrange cover-glass cultures.

The following summary of our observations from these is rendered here. The hyphæ grow both free and submersed in the substratum. The latter, which have dented, raised walls, after a time turn greenish olive-brown and are surrounded by a somewhat granulous, occasionally distinctly brown-coloured, mucous sheath. Their average thickness is 5 μ, but locally as much as 15 μ may occur. The hyphæ display a tendency to form threads, but do not hang very firmly together. The

cells of the aerial hyphæ are narrower, cylindrical and of about the same thickness. Their mucous vagina which gradually becomes very distinct is thinner and homogeneous. Conidial development commences almost immediately from the hyphæ, but in very simplified forms; the characteristic, very complicated conidial clusters peculiar to the species are only formed by degrees. In fig. 56 have been brought together a few examples of the earliest variations of the conidial formation. Long, non-ramified hyphæ begin to constrict conidia from the apex in uninterrupted succession. From this no moniliform chains, however, result, for the conidia are isolated directly they are complete, although they remain united in a group outside the budding hyphal apex. The conidial production does not take place by purely terminal cell-formation — possibly with the exception of the first conidium which is separated by one hypha — for the buds appear as a lateral protuberance at the base of the still attached cell (fig. 56 *a*, *c*) which in this way is forced slightly to one side. There occur thus on the apex of the hypha never more than 2 cells at a time. In ordinary slides in water one never sees this type, because the almost ripe conidium is immediately detatched; it is only the very young, lateral buds which remain.

Irregularities occur occasionally in this primary conidial formation. For example, in fig. 56 *b* it is seen how the two original terminal cells of a hypha have been isolated, and that subsequently conidia began to establish themselves from the new upper cell. Lateral conidial formation is not very unusual either. It may begin as a protuberance on the hypha immediately under a transversal wall, in which case the part or the hypha located above is not isolated; it may also develop directly above the transversal wall, and it can finally be localised to the centre of the elongated hyphal cell (fig. 56 *c*, *d*). Sooner or later the hypha commences ramification and the conidial formation is repeated in the same manner from the branches.

There is no difficulty in proving in plate-cultures how the conidial clusters are established. Here one can trace all the intermediate stages between the non-ramified, vertical hypha with incipient conidial formation and the more composite hyphal systems (fig. 57 *a*, *b*). New branches appear in varying numbers immediately below a transversal wall on the main axis and soon attain the same strength as the latter above the junction of the branches. On this the principal ramification is carried further and further, resulting in a compact, penicillated collection of hyphæ. Its proximal axial portions consist of comparatively short and swollen cells, with the same dark-brown colour that characterizes the substratal

hyphæ, but with an increasing ratio the branches decrease in size and the colour pales. The ends constricting the conidia are narrow, longicellular, and completely hyaline. The conidial clusters generally appear as branches on the substratal hyphæ close to their apex. It also happens, however, that older hyphæ with dark-brown walls throw out young,

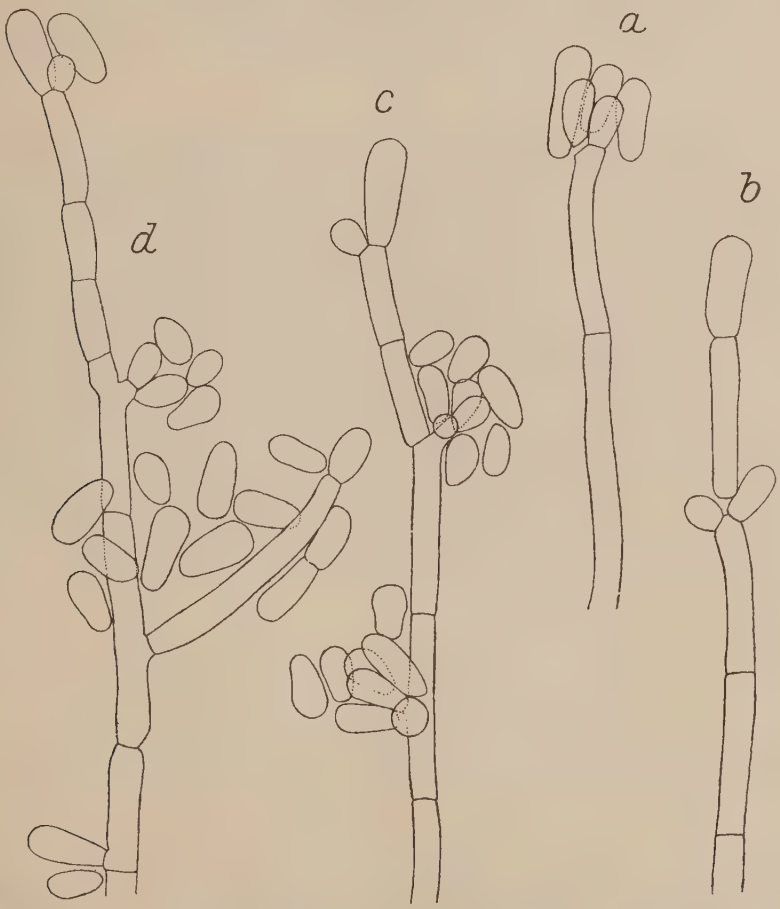


Fig. 56. *Leptographium Lundbergii.* The earliest stages of conidial formation from a cover-glass culture. (cf. p. 250). (× 1125).
De tidigaste stadierna av konidiebildning i en täckglaskultur (jfr sid. 250). (× 1125).

hyaline branches, separately or in groups (cf. fig. 57 *c*), which develop into conidial clusters. A slightly deviating type of an earlier stage of development is reproduced in fig. 57 *d*. The cells display a greatly swollen and abbreviated form which is probably due to unfavourable conditions of nutriment. The material was taken from hyphæ

which grew on the glass-wall of a Petri-dish, rather far above the agar-layer.

The conidial clusters may ultimately become quite large and can be seen without difficulty with the naked eye. Those reproduced in fig. 58 belong to the smaller ones; of these the first *(a)* has appeared in a cover-glass culture and has all its conidia in an undisturbed position. Fig. 58 *b* shows a cluster from a plate-culture, immersed in water under a

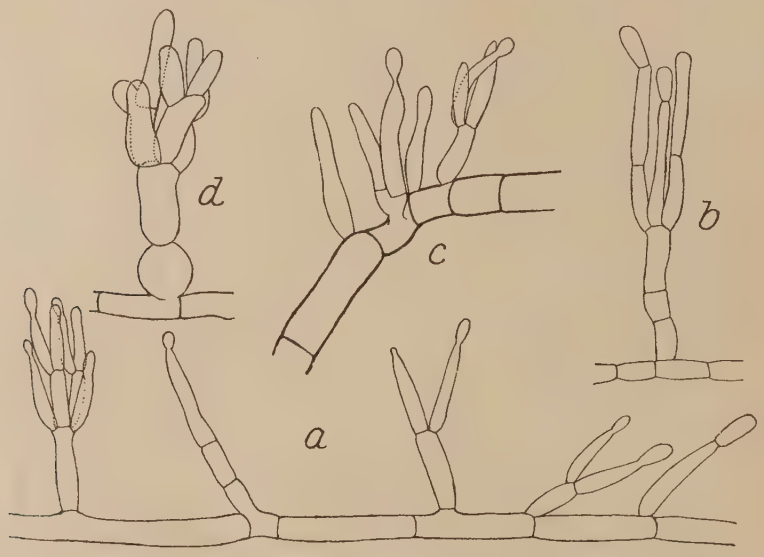


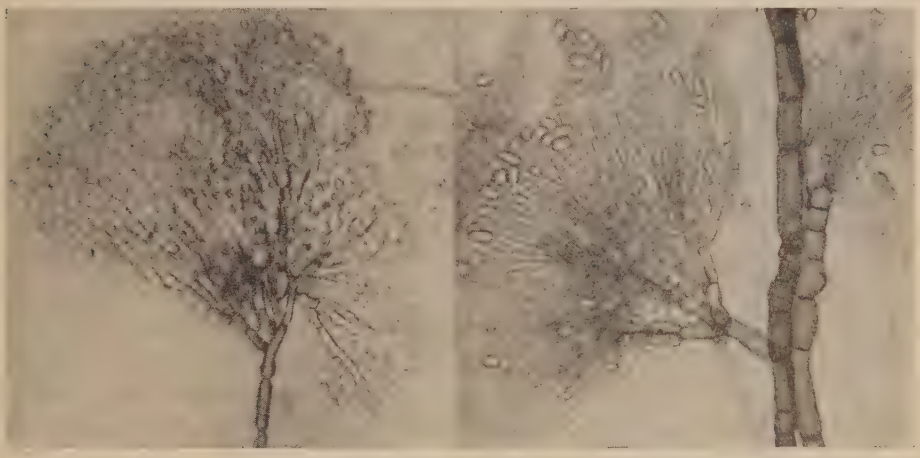
Fig. 57. *Leptographium Lundbergii*. *a*, *b*. The earliest stages of development of conidial clusters on a colourless substratum-hypha. *c*. Older, dark-coloured hypha with inceptions of conidial stocks. *d*. Abnormal inception of conidial stock (× 630). Pure culture on malt-agar.

a, *b*. Konidiesträllningarnas tidigaste utvecklingsstadier å en ofärgad substrathyf. *c*. Äldre, mörkfärgad hyf med anlag till konidiesträllningar. *d*. Abnormt anlag till konidiesträllning (× 630). Renkultur på maltagar.

cover-glass; the majority of the conidia are here removed and the system of ramification is seen more clearly.

The conidia are unicellular, hyaline, elongated with obtuse ends, and taper slightly towards the former point of insertion. The size varies slightly, which at least in respect of the agar-cultures seems to be connected with the fact that they increase in volume after they have been isolated. The length is generally equal to double the width, measured at the upper end, and the measurements vary between 12 × 6 μ and 8 × 4 μ. In older cultures one finds loose conidia with brown-coloured membranes, a change which is also discernible by the naked eye through the gradually darkening conidial masses.

As *Leptographium Lundbergii* must be characterized as quite a distinct type, one might expect that it had been previously observed. We have reasons to believe this, although the independent position of the fungus has not been ascertained. Our fig. 58 *a* agrees very nearly with one supplied by FALCK (1916, fig. 82 *c*) of a conidial stage which, in his opinion, belongs to *Ceratostomella Piceæ*; it is evident that both illustrations refer to the same fungus. FALCK also points out (p. 141) that this »stage» appears as a rule separately, a circumstance which



a Photo by E. Melin. *b* Photo by T. Lagerberg.

Fig. 58. *Leptographium Lundbergii*. *a*. Conidial cluster with undisturbed, superficially enriched conidia from a cover-glass culture (× 280). *b*. Conidial cluster from culture in Petri-dish layed in water under cover-glass, with conidia removed (× 350).

a. Konidieställning med orubbade, ytligt anriktade konidier från en täckglaskultur (× 280). *b*. Konidieställning från kultur i petri-skål; preparat i vatten under täckglas med avlägsnade konidier (× 350).

confirms the accuracy of our opinion concerning the same. If *Leptographium Lundbergii* has grown intermixed with the material from which FALCK isolated his *C. Piceæ*, one can readily understand why he ascribed to this species the power of intensive blueing, whereas in reality it is of subordinate importance in this respect (cf. Plate I). In the aforesaid work by MAC CALLUM there occur one or two illustrations which are worthy of special attention in this connection. Plate VIII shows a reproduction of the terminal section of a pine-log which had been felled when living, and reveals a sapwood zone which »by a mixed infection of fungi» was intensely blued. On Plate IX, fig. 1, is illustrated a radial section of the same sapwood. The illustration shows a net-

work of dark hyphæ on the surface of the log, from which a number of penicillated conidiophores grow, whilst the tracheids contain thick, dark-coloured hyphæ which penetrate further through the pith-rays. In the accompanying explanation of the illustration special stress is laid on the fact that the thick hyphæ are often met with in pith-rays whose cells have been destroyed. The illustration is scarcely mentioned in the text, which may possibly be interpreted to the effect that the author considers the conidial stage illustrated as being connected with *C. Piceæ* which is the real object under examination. In our opinion an attack by *Leptographium Lundbergii* has, however, been depicted in the illustration quoted. The conidial clusters have certainly been drawn in a somewhat summary manner, but in their shape they unmistakably resemble those which occur in this fungus. Moreover, the development of the hyphæ in wood displays very great similarity. There should therefore be no doubt that *Leptographium* has been met with both in Germany and in England, and one is certainly entitled to assume that the fungus is very widely disseminated. It may here be added that in the blued pine log from which we ourselves isolated *C. cærulea*, there grew also a mycelium which fully resembled a *Leptographium* mycelium, although its identity in this case was not proved in pure culture.

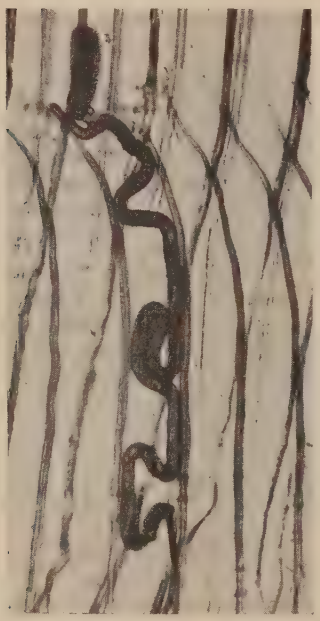


Photo by T. Lagerberg.

Fig. 59. *Leptographium Lundbergii.* Hypha with convolutions in the apex of a tracheid (× 115). Hyf med slyngor i spetsen av en trakeid (× 115).

On wood the fungus develops a fairly strong, grey-brown to dark-brown air-mycelium — stronger on pine than on spruce — through which the discoloured sapwood appears greyish-blue. Conidial clusters of generally a spherical or ellipsoidal shape develop profusely. Their colour is mostly of a pale honey-tint to golden-brown. As a blueing fungus *Leptographium* is a very active form and imparts within a short time a very distinct grey-black discoloration to the sapwood of pine-timber. The profusion of coarse, vertical hyphæ in the tracheids is particularly remarkable. Their thickness reaches 15 μ, the membrane is dark-brown and quite glossy, and the cells are large, containing quite a large quantity of drops of oil. The ramification is often rather sparse,

and one and the same unbranched hypha can be traced under the microscope through a whole series of tracheid levels. An occasionally extremely convolute arrangement of the tracheid hyphæ seems to be characteristic of this species in the manner illustrated in fig. 59. Such types recur more or less numerously in all slides. Or the coarse hyphæ force their way up through the tracheids in a spiral adjoining their walls. The ramification seems to a certain extent to be influenced by the position of the borderad pits. For instance, we have observed that several pits in succession (5) were filled with short branches which issued at right angles from the hyphæ growing past them. The bordered pits form the only possible passage for the hyphæ between the tracheids. Direct perforations are lacking, a fact which emphasizes the independence of this fungus as compared to *C. Piceæ*.

The pith-rays are also more or less completely filled with coarse, brown hyphæ, which here and there produce short appendicatory projections and also similar branches separated by walls, which are so closely congested that the parenchyma cells seem to be entirely replete with pseudoparenchymatous tissue. Hour-glass shaped contractions of the parenchyma cells occur, especially in autumn wood, but they are not so distinct, possibly due to the growth and penetration of the hyphæ proceeding very rapidly. The vertical resin-ducts are seen on the radial section as fine black lines; the hyphæ are here also very profusely developed and occur in real convolutions in which the branches are partly anastomose or develop locally into pseudoparenchymatous agglomerations.

Leptographium Lundbergii behaves rather erratically in spruce. From Plate II it will be seen that comparative culture-tests on pine and spruce-timber turned out quite differently, although the inoculated sectors of logs possessed as nearly as possible the same rate of growth, and the conditions of culture were identical. In the case in question the spruce did not show the slightest trace of discoloration. In other tests, however, the fungus developed quite distinct blueing, though perceptibly fainter than that which occurs in pine.

It now remains to discuss the position which ought to be ascribed to *Leptographium Lundbergii* in the system. By its dark mycelium and the nature of its conidial formation it immediately betrays itself as belonging to the *Dematiaceæ*, and the unicellular conidia relegate it to the division *Phæosporæ* Sacc. of the same family. In our opinion only one of the sub-divisions possessing hyaline or almost hyaline conidia, — viz. *Stachylidieæ* Sacc. — can be taken into consideration here. To the same are assigned the genera *Stachylidium*, *Scopularia* and

Fuckelina of which the first and the last do not present any resemblance to our fungus. The genus *Scopularia* with the only species *venusta* Preuss attracts, however, considerable attention from a comparative point of view. This fungus was found on pine at Hoyerswerda and was described by its discoverer in 1851. In his work on the *Dematiaceæ* published by LINDAU in 1907 he states on p. 744 that it has not been rediscovered later on. The original description could therefore not be completed and improved, which the author considers would have been very desirable. The diagnosis may reasonably be suspected of being somewhat erroneous, and the accompanying illustration of the fungus contains certainly several faulty details. At any rate, there remain sufficient particulars of whose accuracy we need not doubt, in order to draw a comparison between *Leptographium Lundbergii* and *Scopularia venusta* which may seem justified. The latter is described in the following manner: The ramified mycelium occurs superficially on the substratum (pine) or penetrates into it. Conidiophores upright, dark in colour, scarcely ramified (non-ramified), at the top repeatedly ramified penicillated with colourless (»blass») branch-apices forming conjointly an oval head. The hyaline, oval conidia are unicellular, develop terminally and are united by a mucus with the branches into a sphere. All these particulars fit nicely *Leptographium Lundbergii*. The habit illustration given on a less magnified scale shows a piece of pine-wood in radial section, with a number of penicillated, fairly long-stemmed conidiophores rising from the surface, but furthermore also strong, dark-coloured hyphæ which penetrate into the wood in a cluster right across the tracheids. It is evident that these streaks of hyphæ on the section have been developed in a pith-ray.

The ramification which is said to distinguish the penicillated termination of the conidiophors in *Scopularia venusta* exhibits, however, definite differences between the two fungi. According to the description the branches should be opposed, non-septate, downwardly gapingly connected with each other and upwardly greatly angustated. SACCARDO (1886, p. 330) in rendering this description in his »Sylloge fungorum» has doubted the reversed position and in all probability he is right. One may for equally good reasons venture to assume that the vaginal junction of the basal portions of the branches and the absence of transversal walls which can be seen very distinctly in the strongly magnified detailed illustration, and has there been reproduced with almost diagrammatic accuracy, is nothing but artificial products. As these particulars in any case, are recorded and there is no way in which they can be verified, we did not deem it advisable to consider *Leptographium Lundbergii* and *Scopularia*

venusta as identical forms, although much may be said in favour of such being the case. We therefore prefer to describe the former as a new type.

Leptographium LAGERBERG et MELIN nov. gen.

Mycelio fuligineo, fibrilloso-intricato, hyphis fertilibus erectis, uni- vel pluricellularibus, ramis iterum iterumque verticillato-ramosis apice dense penicillatis. Conidiis continuis, mox deciduis, ex apicibus ramulorum ultimorum non vere terminaliter orientibus sed ad basin conidii maturi semper unici adhærentis subterminaliter productis, capitulum quasi mucosum diu formantibus.

L. Lundbergii LAGERBERG et MELIN n. sp.

Mycelio epi- et entoxylino. Ramulorum conidiigerorum sensim pallescentium apicibus omnino hyalinis. Conidiis hyalinis, ovoideis vel pyriformibus, 8—12 × 4 — 6 μ, sensim dilute brunnescentibus. Hab. in ligno *Pini silvestris*. — Forsan *Scopulariæ venustæ* Preuss synon.

Cadophora fastigiata LAGERBERG et MELIN nov. gen. et sp.

This fungus has been found in the following localities:

1. Dalecarlia, Garpenberg 29. 7. 1923. On pine-timber from storage tests.
2. Västmanland, Bjurfors 10. 8. 1924. On pine-planks in the timber-yard.
3. Dalecarlia, Torsång, Dec. 1924. On floated spruce-timber, obtained from the Dalecarlian Timber Floating Association.
4. Ångermanland, Marieberg, Aug. 1925. On sawn spruce-timber.
5. » , Svanö, Aug. 1925. On sawn spruce-timber, partly together with *Hormonema dematioides* and *Hormodendrum cladosporioides*, partly also together with *Hormonema dematioides* and *Ceratostomella Piceæ*.
6. Ångermanland, Kramfors, Sept. 1925. On sawn pine-timber: alone; together with *C. Piceæ;* together with *Hormodendrum cladosporioides;* together with the last-mentioned and *Penicillium biforme*.
7. Värmland, Skoghall Works, Nov. 1925. On sawn pine-timber, together with *Penicillium biforme*. On sawn spruce-timber: alone, together with *Hormonema dematioides, Hormodendrum cladosporioides* and *Penicillium biforme;* together with *C. Piceæ;* together with *C. Piceæ* and *P. biforme*.

Here we encouter again a previously unknown fungus which, however, seems to be very widely distributed. On malt-agar it develops a compact air-mycelium, pale-grey or pale greyish-green in colour, which gradually turns more or less grey-brown (fig. 60). The under-side of the colonies finally turns brown-black or pure black. Their development is slow, the rate of growth being only 1,2 (cf. note p. 164).

The earlier stages of the mycelium have been examined in cover-glass cultures. The growing hyphæ are narrow (about 3 μ) and remarkably even. The membrane is olive-green and smooth; exudation is

absent on the whole also in older hyphæ. Their cells are long, but are not always very distinct on account of the large moniliform drops of oil with which they are filled (cf. fig. 61 *e*). Here and there rows of shorter cells are noticeable which are sometimes almost spherical, or ellipsoidal to pear-shaped, and whose diameter may rise to 7 μ. The mycelium has a great tendency to develop threads (fig. 62, 63). In plate-cultures there develop thus whip-lash-shaped coremia several millimeters in length, which may contain at the base over 50 agglutinated

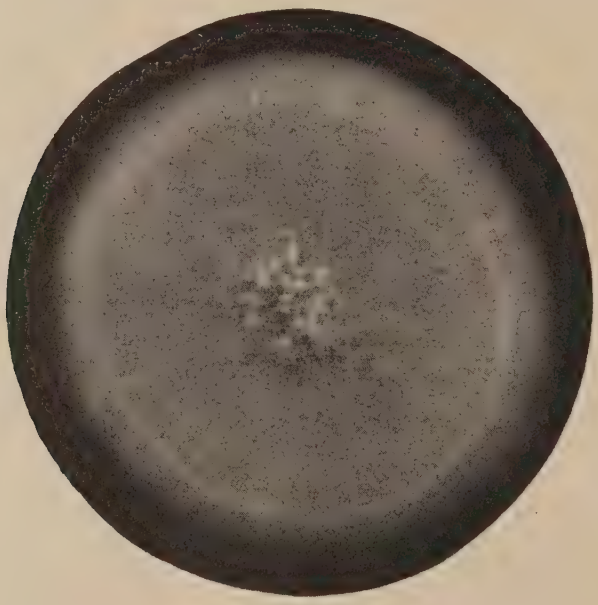


Photo by E. Melin.

Fig. 60. *Cadophora fastigiata.* Pure culture on malt-agar (× 115).
Renkultur på maltagar (× 115).

hyphæ, but upwardly become more and more attenuated when the separate hyphæ are released from the thread and develop conidial clusters (fig. 63).

Conidial formation occurs, however, long before the coremia have come into existence. In cover-glass cultures it had become very active in a week. It belongs to the endogenous type which is on the whole rather uncommon among the *Hyphomycetes* — on this account the fungus must be placed in the sub-division of *Chalareæ* of the *Dematiaceæ*. The conidia originate in receptacles which vary somewhat in shape. They are generally short, and owing to the swelling on the lower

part distinctly ampullaceous, but unsymmetrical from flexion. As a rule a clearly marked neck-like constriction occurs under the opened top, the mouth widening out like a funnel. The conidiogonia are 9—10 μ in length and about 3 μ in width (fig. 61 *a*—*d*). Another type is more elongated and straight (61 *e*); the receptacle forms a direct continuation of the hyphal branch. The apex often appears here as a

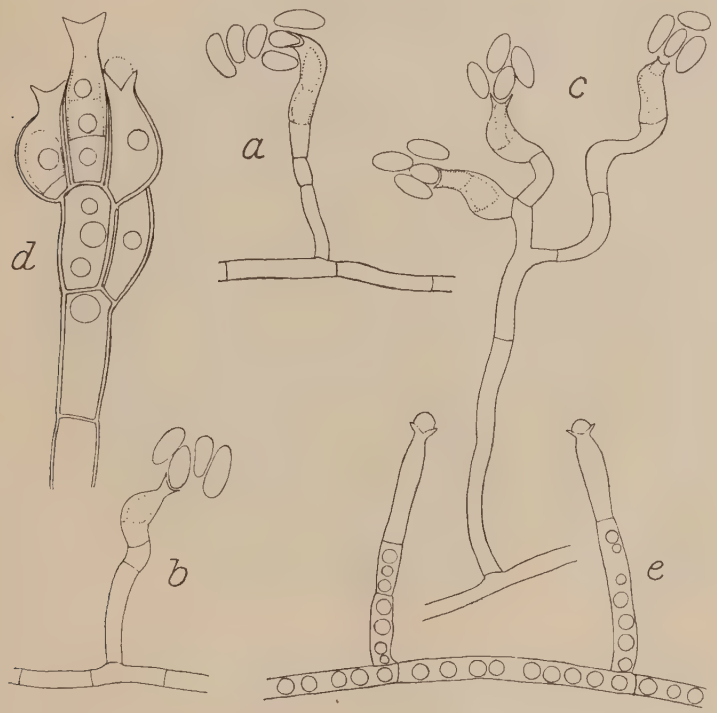


Fig. 61. *Cadophora fastigiata*. *a*—*c*. The earliest stages of conidial formation in a cover-glass culture. *d*. Cluster of conidiogonia of more compact type from a thread in the air-mycelium (× 2175). *e*. Conidiogonia of an elongated type (× 1125).

a—*c*. De tidigaste stadierna av konidiebildning i en täckglaskultur (× 1125). *d*. Konidiogonställning av mera kompakt typ från en sträng i luftmycelet (× 2175). *e*. Konidiogon av långsträckt typ (× 1125).

sphere, imprisoned in an infundibular cuff, a feature due to a conidium being about to pass through the opening. In the cover-glass cultures the conidiogonia were in the simplest case deposited separately on longer or shorter lateral branches of the substratum hyphæ (fig. 62, fig. 61 *a*, *b*, *e*), but frequently the vertically growing air-hyphæ commence ramification first, by which means more complicated clusters are developed (fig. 61 *c*, *d*). The separate conidiogonia are here first deposited terminally, but very soon new sub-terminal and even lateral ones

are added (fig. 61 *d*), and the cluster is by this means so much condensed that it is only with difficulty that its details can be studied under the microscope. The whole collection becomes scopiform or spherical and looks under a magnifyng glass like a dark sphere. In one instance over 50 conidiogonia could be counted in such a one. Masses

Photo by E. Melin.

Fig. 62. *Cadophora fastigiata.* Ampullaceous conidiogonia with the produced conidia collected outside the orifice. On top to the right a hyphal thread. Cover-glass culture on malt-agar. (× 450).

Flasklika konidiogon med de producerade konidierna samlade utanför mynningen. Upptill till höger parti av hyfsträng. Täckglaskultur. (× 450).

of these more or less composite conidial clusters on fairly short stems always develop from the coremia (fig. 63).

On account of the minuteness of the material it is not safe to determine the origin of the conidia in their receptacles. In cover-glass cultures, however, one sees immediately that several conidia are developed from one and the same receptacle (fig. 62; fig. 61 *a*—*c*), which must be due to intercalary, repeated cellullar divisions. One can also in many cases clearly distinguish a fine transversal wall which adjoins a basal cell in the bottom of the receptacle; it is probably through partitions in the latter that the conidia are detached. In older cover-

glass cultures one can find numerous, perfectly empty conidiogonia, from which one may conclude that their production ceases sooner or later. The extent of this does really not appear to be particularly overwhelming, for as the conidia remain lying in a group outside the mouth of the receptacle in which they have originated it is possible by counting them to arrive at an estimate as to the activity of the conidiogon. Such a count resulted in slightly over 50 conidia. In conclusion it should, maybe, be added that the conidia never cohere in chains, but are isolated the same moment they are fully developed. The conidia are unicellular, ellipsoidal, exceedingly thinwalled, at first completely hyaline, but in time faintly brownish. The length varies between 4 and 6,7 μ, and the thickness between 2 and 2,7 μ. They generally contain one or two large drops of oil.

Photo by T. Lagerberg.

Fig. 63. *Cadophora fastigiata.* Hyphal thread from the air-mycelium with lateral conidial clusters (× 115). Pure culture on malt-agar. Hyfsträng ur luftmycelet med laterala konidiestållningar (× 115). Renkultur på maltagar.

On timber *Cadophora fastigiata* develops a pale-grey to mole-coloured air-mycelium which grows rather more vigorously on pine than on spruce. Active conidial formation very soon takes place from the same. The hyphæ easily penetrate pine, imparting to it an intense, black-grey discoloration (Plate II). They are found in quantities in the parenchyma of pith-rays and their manner of growth there, and general appearance, indicate a certain resemblance to *Ceratostomella pluriannulata.* The hyphæ retain their type unchanged from the agar-cultures, i. e. they are light-brown, uniformly slender (about 3 μ), and full of uniformly large drops of oil in moniliform rows. When they occur congested in a pith-ray the latter appears at first sight to be filled with a homogeneous, light-brown, close-grained substance. The hyphæ in the parenchyma of the the vertical resin-ducts develop in the same way. They also grow profusely in the tracheids, especially in the spring-tracheids, where they appear to become somewhat thicker (4—5 μ) and more irregularly sinuated, but the colour of the membrane always remains fairly faint. The hyphæ are capable of perforating the tracheid walls direct, developing adpressoria of the same type as those in the *Ceratostomella*-species.

The behaviour of the fungus in spruce varies considerably. Sometimes blueing remains entirely absent (cf. Plate II). On examining some spruce infected by such a one, but which had not altered externally, hyphæ could certainly be distinguished in the outer rings, but they were sparse and exceedingly fine (about 0,5 μ thick); they occurred almost as much in the parenchyma cells as in the tracheids. Otherwise there occurs on spruce inoculated with the fungus blueing of almost the same intensity as on pine.

We shall hereafter pass on to an analysis of the systematic position of the fungus. One would hardly be able ty believe that a form as characteristic as the one in question, and apparently also widely distributed, should be missing in systematic literature, but such is clearly the case. Our researches in this direction have, at any rate, not led to any result. There was, however, published in 1925 in North America paper concerning the damage done to stored wood-pulp and pulp-wood (cf. KRESS etc). The main treatise is supplemented by an article dealing with all the forms of fungi which were found to be connected with this damage. Mention is here also made of several different types of the *Dematiaceæ*, of which four have been identified as to the genera, the others are described without names. Amongst the latter N:o 2 attracts special attention. According to statement it appeared very generally on both mechanical and sulphite pulp. The accompanying drawings, Pl. XVI, fig. 6 and two microphotographs enlarged 150 times, Pl. XX fig. 3 and 4, prove undoubtedly that this North American fungus is identical with *Cadophora fastigiata* investigated by us. The former is described in the following manner:

»Cultures mouse gray, drab, or dark snuff brown, reverse brown-black; mycelium downy, cottony, or fluffy to feltlike; conidiophores branched or unbranched, lateral branches of ordinary hyphæ, hyaline to light brown, ends open to form a »collar» wich is slightly flaring (Pl. XVI, fig. 6) and concolorous with conidiophore, bell shaped and dark brown (Pl. XX, fig. 3) or widely flaring, sauer shaped and dark brown (Pl. XX, fig. 4). Conidia borne singly at tips of conidiophores, held together in heads; hyaline, subhyaline, or light brown; ovoid, ellipsoid, or globose.»

The variation in the appearance of the conidiogonia, which is connected with the variations in the method of opening the apex, and which is strikingly illustrated in the aforesaid diagnosis, recurs in all details in our material. The dark, or occasionally lighter, colour of the collar may nevertheless be mainly an optical phenomenon. The diagnosis contains, however, a statement which does not fit our fungus. In the North-American form the conidia are said to originate singly at the apex of

»conidiophores», but there is no mention of the way in which this occurs. If we now compare this statement with the author's fig. 6, Plate XVI, we get no confirmation from the figure that the description of the conidial formation is correct. For the figure indicates quite clearly the endogenous method of development which we have minutely described above; conidiophores in a more limited sense consequently do not occur.

In our opinion there is a sufficient reason for the assumption that *Cadophora fastigiata* is represented both in the Old World and the New. In America it has already been classified amongst those forms of fungi which are of practical interest to the wood-pulp industry. For us it will probably hardly assume any importance in this direction, but rather as a timber-bluer, inasmuch as it is a common visitor to our timber-yards and stores.

Cadophora LAGERBERG et MELIN nov. gen.

Hyphis repentibus, griseo-fuscis. Conidiis endogenis, continuis, e thecis plus minus lageniformibus, ostiolo infundibuliformi præditis.

C. fastigiata LAGERBERG et MELIN n. sp.

Hyphis epi- et entoxylinis, rectis, circ. 3 μ crassis, sæpe fasciatim contextis e cellulis sat longis, fuscis, guttulis fartis, compositis. Thecis brevibus et ad basin plus minus inflatis, vel longioribus et fere cylindraceis, in apicibus ramorum hypharum singulatim vel fastigiatim aggregatis, hyalinis vel sensim brunnescentibus. Conidiis ellipsoideis, hyalinis vel plus minus fuscis, $4-6{,}7 \times 2-2{,}7$ μ. Hab. in ligno *Pini silvestris* et *Piceæ exselsæ*.

Alternaria humicola OUDEMANS.

This fungus is met with in a single instance:

1. Gästrikland, Bomhus, 23. 11. 1925. On blued pine-timber in a timber-yard.

A dense air-mycelium of an at first white, subsequently grey-green to olive-green, and finally dark-brown colour is developed on malt-agar (fig. 64). The under-side of the colonies is black-green. Their rate of growth is 2,8 (cf. note p. 164). In cover-glass cultures the following observations could be made. The hyphæ are as a rule longicellular, with a thickness varying between 3,5 and 6 μ. Occasionally the cells are swollen at one end, but just as often on both, in which latter case the cells become dumb-bell-shaped. Other forms of mycelia develop, however,

locally. The cells are then very short and slightly swollen, greenish-olive-brown in colour, and the hyphæ form convolutions and anastomoses (fig. 65), which in time condense into pseudoparenchymatous sheets of a black-green colour. Such occur plentifully in pure culture, but we have not been able to ascertain their importance.

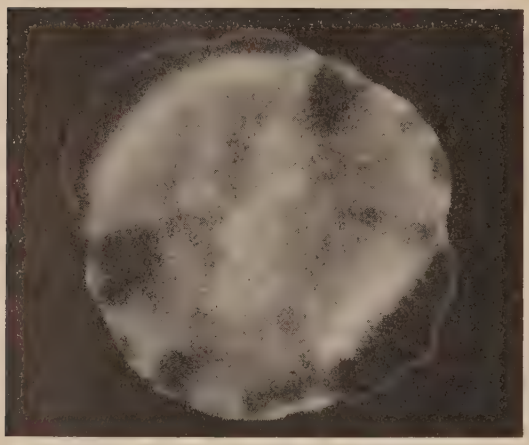


Photo by E. Melin.

Fig. 64. *Alternaria humicola.* Pure culture on malt-agar (× 1,2).
Renkultur på maltagar (× 1,2).

The conidia distinguishing for the species soon begin to establish themselves. They occur as unicellular chlamydospores in which, however, an animated developement of walls is soon introduced (fig. 66 *a*). They are frequently established in rows with single cells as an intermediate link, or also in more or less composite, racemose groups, which are supported by short lateral branches upon the substratum hypæ (fig. 66 *b*, *c*). The occasionally rather long chains of conidia may easily give rise to the idea that one has developed from the other and that the terminal ones should thus be the youngest. In reality, the opposite is, however, the case. The terminal conidium is the oldest, and the new conidial development progresses basipetally. The inverted claviform shape distinguishing for the genus occurs soon. In a ripe state the conidia are murally divided by up to 7 transversal walls, on which faintly distinguishable constrictions occur. The membrane is at first yellow but turns finally dark-brown or blackish olive-brown, and assumes a fine chagreening of irregular, angular laminæ (fig. 66 *d*). The form varies very much, which is

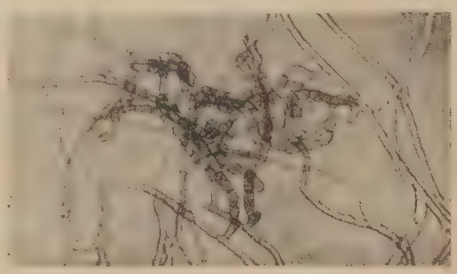


Photo by T. Lagerberg.

Fig. 65. *Alternaria humicola.* Commencing sclerotial formation in the air-mycelium. Cover-glass culture on malt-agar (× 115).
Begynnande sklerotiebildning i luftmycelet. Täckglaskultur på maltagar (× 115).

Fig. 66. *Alternaria humicola*. *a*, *b*. Conidial formation (× 630). *c*. Hyphæ with conidial clusters. *d*. Conidia (× 1200). Pure culture on malt-agar.

a, *b*. Konidiebildning (× 630). *c*. Hyfer med konidieställningar. *d*. Konidier (× 1200). Renkultur på maltagar.

chiefly due to the length being far from fixed; the breadth, on the other hand, seems to be less variable. Our measurements have resulted in the following values: 21,4—53,6 × 14,3—17,9 μ. OUDEMANS (1902, p. 292) gives as the largest measurement 50 × 16 μ.

The fungus penetrates with ease into pine-timber, which assumes a greenish-grey discoloration (Plate II). The hyphæ growing in the parenchyma of the pith-rays are straight, little ramified and 5—7 μ thick; occasionally they entirely fill up the gap between the marginal cells. The walls are as a rule thin and faintly brown, the cells themselves cylindrical and entirely filled with very minute drops or a cohesive mass of oil. The parenchyma cells display strong contractions like an hour-glass. Convolutions of hyphæ with short and swollen, dark-brown cells occur in the parenchyma of the vertical resin-ducts. Even in the tracheids hyphæ are common, generally fairly straight but with plenty of lateral branches; the latter are found to posses a pronounced capacity of penetration and develop globular adpressoria. In the spring-tracheids there could in several places be observed a change in certain portions of hyphæ, which must probably be interpreted as a commencing conidial development. Several cells in succession were here clearly swollen and had commenced to undergo secondary division.

The fungus grows slower in spruce-timber (cf. Plate II), the discoloration mainfesting itself only as a dirty-greenish tint. The hyphæ in the wood proved also to be feebly developed. They grew more irregularly in the pith-rays; the membrane was thin and almost colourless, and the had globular swellings. In the tracheids the bulk of the hyphæ seemed to grow in a radial direction, and their perforations were remarkably common.

The genus *Alternaria* komprizes quite a large number of species, several of which are known as dangerous parasites on leaves and fruit. It is only insufficiently known of what higher forms of fungi they form the conidial stage. BREFELD (1891, p. 225, Pl. VII, fig. 69, 70), has, however, discovered that the genus *Pleospora* of the *Pyrenomycetes* has conidia of a perfect *Alternaria*-type. Even in connection with the blueing of timber these conidial fungi have been the subject of investigation. Thus HEDGCOCK (1906, p. 103) includes *Alternaria tenuis* Nees in the group which caused blueing of the sapwood but without any closer description.

Later on, too, a species which had not been fully determined has been treated in practical mycological literature. KRESS and his collaborators (1925, p. 65), have namely discovered an *Alternaria* to be common in mechanical pulp, on which it caused small round, brown stains.

The mycelium is described from pure cultures as velvety, pale to olive-green, and black on the under-side. The conidia were inverted claviform, single or in chains — such a one containing 12 is mentioned — and originate at the apex of short conidiophores; ramifying conidial chains had also been observed. The description which accompanies the figure points to a fairly good agreement with *Alternaria humicola*, but as information is missing, both as to the size of the conidia and the nature of their membrane, identification is impossible.

OUDEMANS isolated *Alternaria humicola* from a humus-sample from the Spanderswoud Forest, near Bussum in Holland. As the fungus, therefore, in the first instance is a humus-fungus, it may also be surmised that it would be widely disseminated.

Xylomyces I.

The fungus has been met with in a single instance:

1. Dalecarlia, Garpenberg 23. 11. 1923. Together with *Stereum sanguinolentum*, isolated from a spruce-log which was included in the storage tests.

Under the above provisional designation we are here presenting a mycelium which, in spite of prolonged culture upon the most varied substrata, could not be induced to reproduce itself. As a blueing fungus it has, however, proved to be so active that we do not wish to pass it over in our paper. In its general habits the fungus reminds one very much of the equally sterile mycelium which one of us (MELIN, 1921, p. 196; 1923, p. 223) had isolated from the mycorrhiza of conifers, and which had been called *Mycelium radicis atrovirens*.

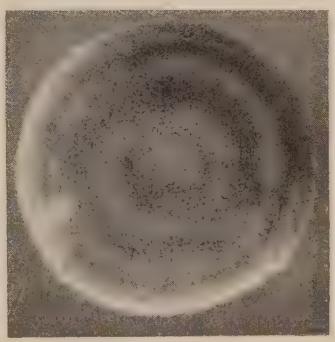


Photo by E. Melin.

Fig. 67. *Xylomyces* I. Pure culture on malt-agar (× 1,3). Renkultur på maltagar (× 1,3).

The development of the fungus upon malt-agar proceeds very slowly; the rate of growth is only 1 (cf. note p. 164). The air-mycelium, however, gets dense and strong (fig. 67) and its colour in the beginning is mole, subsequently grey-brown. The under-side of the colonies is black-brown.

The mycelium grows approximately equally strongly on pine as on spruce. A faint olive-green tint, which gradually changes to grey-brown, develops here in the air-hyphæ. The capacity of penetration has been different in different tests, but on the whole the most intense

blueing occurs in pine. The fungus is properly characterized by its narrow, even and longicellular hyphæ, which in pine have been found to be replete with big drops of oil, arranged in rows. In this it manifestly resembles *Cadophora fastigiata*. In the pith-rays the hyphæ, with a thickness of about 3 μ, are lying closely packed and apparently colourless in fascicles of 8 to 10 in each. These fascicles appear as mutually separated filaments at equal distances with contractions like an hour-glass, which is the result of the changed form of the parenchyma cells. It was possible by means of chlor-iodide of zinc to demonstrate the extremely thin and otherwise invisible cellulose membrane which surrounded every fascicle of hyphæ. Even the vertical parenchyma cells of the resin-ducts are completely filled by similar narrow hyphæ. Their walls are throughout thin, smooth and faintly olive-brown. Those growing in tracheids are generally only 1,5—2 μ thick, and their ramification occurs at a very sharp angle, for which reason all hyphæ appear to be parallel. No direct perforations occur.

The course of development of the fungus in spruce-timber proved to be similar to that in pine-wood, for which reason a detailed description is not necessary here.

Penicillium biforme THOM.

The above species has been obtained in pure culture from the following localities:

1. Gästrikland, Bomhus, Sept. 1925. From sawn pine-timber.
2. Ångermanland, Kramfors, Sept. 1925. From sawn pine-timber: alone; together with *Cadophora* and *Hormodendrum cladosporioides*.
4. Värmland, Skoghall Works, Nov. 1925. From sawn pine-timber: alone; together with *Ceratostomella cœrulea;* together with *Cadophora*. From sawn spruce-timber: together with *Hormonema dematioides*, *Cadophora* and *Hormodendrum cladosporioides*.

The many species of the genus *Penicillium*, which live upon the most varying organic substrata, are critical from a systematical point of view. As blueing fungi they play a more subordinate part, and naturally only the greenish, more or less dark-coloured, species can here be taken into consideration. Of the other species, some are certainly able to discolour the substratum, but in a different way. HEDGCOCK (1906, p. 104) had in his investigations into blueing fungi an opportunity to study a couple of species of *Penicillium*, defined as *P. aureum* Corda and *P. roseum* Link. The former distinguished itself by a development

of pigment which changed according to the degree of acidity in the substratum. The pigment appeared as an exudation upon the hyphæ, which was easily soluble in water. In an alcaline medium it turned red; in an acid medium, lemon-coloured. *P. roseum* produced a carmine pigment. The discoloration of wood, which was connected with these species of *Penicillium*, was due to the walls of the cells in the wood absorbing in themselves the pigment discharged by the fungi.

In the investigation made by KRESS and his collaborators (1925, p. 63), concerning detrimental fungi in pulp and pulp-wood, a large number of *Penicillia* are mentioned, some of which had a capacity of staining their substratum.

The species of *Penicillium* studied by us develops upon malt-agar a dense air-mycelium, which during the first days has a pure snowy-white colour. With the commencement of the conidial formation the colonies turn light grey-green, but retain a white border (fig. 68). In older colonies even the latter has completely disappeared, because the conidial development has been carried to the very edge. The colour changes in the meantime and finishes with a fairly dark grey-brown, in which only a faint tint of green can be distinguished. The under-side of the colonies remains a dirty yellow-white all the time. Their development progresses on the whole rather slowly; the rate of growth is only 1,3 (cf. note p. 164).

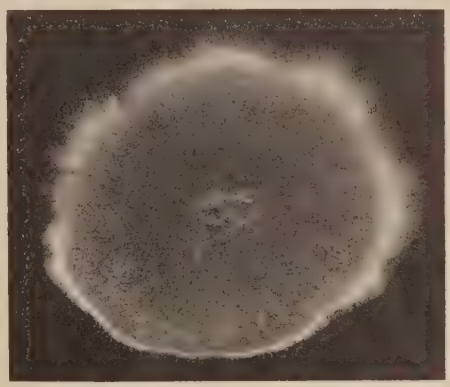


Photo by E. Melin.

Fig. 68. *Penicillium biforme*. Pure culture on malt-agar (× 1,3).
Renkultur på maltagar (× 1,3).

The following observations could be made in cover-glass cultures as regards the general organisation of the fungus. The hyphæ are longicellular, up to 5,5 μ thick, hyaline or faintly green-tinted. Their thin membrane is here and there coated with fairly coarse-grained, colourless and soluble exudations. The formation of conidia takes place chiefly from short, upright lateral branches upon the substratum hyphæ, more exceptionally directly at their apices. In the beginning, clusters of quite a simple type are developed, frequently only consisting of a single, long cell, from whose apex emanate a few sterigmata — metulæ, according to WESTLINGS (1911) terminology. The latter are occasionally

finely rugose and increase slightly in thickness towards the apex; the sterigmata are ampullaceous and smooth. The largest number counted upon one and the same metula is 9. Their size varies rather considerably, according to our measurements between 7,2—12,4 μ in length and 3,6—4,5 μ in their greatest breadth. The whole conidial cluster is quite

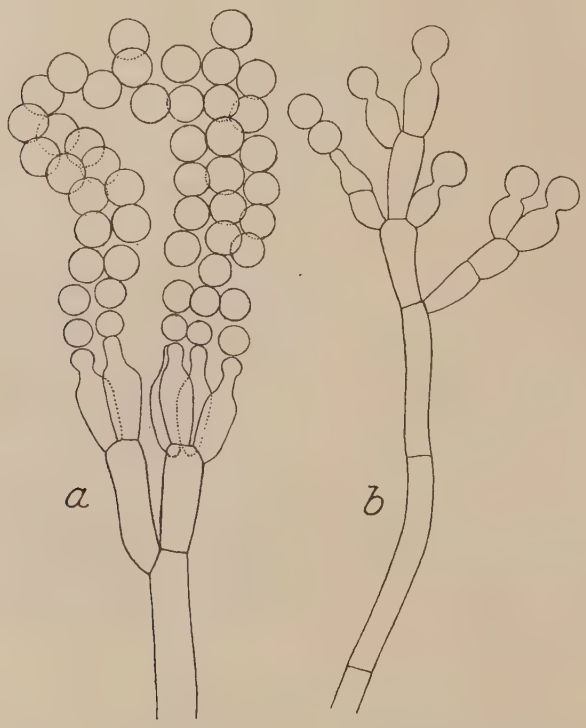


Fig. 69. *Penicillium biforme* *a*. Conidial formation from the air-mycelium (× 1125). *b*. Submerged conidial formation (× 1125). Pure culture on malt-agar.
a. Konidieställning från luftmycelet. *b*. Submers konidieställning (× 1125). Renkultur på maltagar.

narrowly penicillate, and the conidia are held together for a long time in moniliform, sinuous rows (fig. 69 *a*). Their shape is mainly globular — one or two feebly ellipsoidal occurs, however, always in the slides — and their size is fairly uneven; their diameter varies between 4,7 and 3,1 μ. In cover-glass cultures submerged conidial clurters (fig. 69 *b*) of a distinctly different form frequently occured, indicating that development had progressed under adverse conditions.

In older colonies the conidia have changed their colour into a dark olive-green, but their wall is still quite transparent. Another change which in a greater measure attracts our interest has occurred in the mycelium. The hyphæ develop globular protuberances, both terminally and in the centre of separate cells, and these have often a diameter several times that of the breadth of the hyphæ. In a 9 months old culture their walls had thickened very much, although they were still colourless. Large quantities of round grains (fatty oil) were lying in the angustated cell-space, imparting to these formations a certain similarity to a sporangium. The globular protuberances on the hyphæ, which can easily be isolated in the slides, are mentioned already by WESTLING (1911, p. 68) in the case of *Penicillium biforme*, but occur according to the same author also in other species. The description of *P. biforme* given by him fits in all essentials our species, and we have therefore not hesitated to identify them with each other. According to WESTLING this species belongs to the commonest mould-fungi in our country and has been observed upon cheese, oak-bark, fruits of *Hippophaës* and *Rhamnus frangula*, upon root-stumps of *Alpinea officinarum* (drug) etc.

P. biforme develops somewhat more strongly upon pine than on spruce, and the difference does not only extend to the superficial vegetation but in a still higher degree to the hyphæ penetrating into the wood. Upon a radial section of an inoculated piece of pine-wood fine, strongly verdigris-coloured streaks could be discerned by the naked eye. These consisted of broad pith-rays entirely filled by hyphæ with fairly wide and thin-walled cells. All were replete with oil, which could even occur on the outside of the membrane. In the tracheids the hyphæ occur rather sparsely, but in the same way as in *Hormodendrum cladosporioides* the conidial clusters developed within the wood quite generally. At first the spring-tracheids appear to be selected for this purpose, but on the other hand the conidial clusters were not lacking in autumn tracheids. Long stretches were thus crowded with conidia, and it was evident that these very fillings contributed towards the discoloration which could be observed by the naked eye. The same is, however, under all circumstances fairly faint and is distinguished in the cross-section by a certain streakiness (cf. Plate II); it does not reach very deeply below the infected surface. The mycelium also completely lacks the power of perforating the tracheid walls. *P. biforme* is one of the most typical surface blueing fungi.

No discoloration was obtained in the inoculation-tests on spruce. Upon the tangential surface of the log the fungus developed a conidia-producing coating, and the matter seemed to have stopped there. Nevertheless, in the microscope the hyphæ could be followed to a depth of about 1 cm., corresponding to 4 rings, and in the spring-tracheids conidial stocks had been established here and there.

BIOLOGICAL AND PRACTICAL RESEARCHES INTO BLUEING IN PINE AND SPRUCE.

5. The influence of different factors upon the development of blueing fungi.

The factors affecting the development of blueing fungi in wood are in the first instance the water and oxygen content, temperature, and the chemical and physical nature of the timber.

A. Influence of water and oxygen content.

1. Earlier investigations.

The most thorough investigations for determining the relation of the water and oxygen content to the development of blueing fungi in wood have previously been carried out by MÜNCH (1908, 1909). MÜNCH proved the decisive importance of the oxygen content for the development of blueing fungi in timber. The fungi examined were *Ceratostomella Pini* and *C. cærulea*. A first series of tests was made in April, 1907, with *C. Pini*. A 40-year old pine-tree (14 cm. in diameter at breast-height) was cut into 113 cross-sections (5—10 cm. thick) which were weighed and their volume ascertained, after which their specific gravity was calculated. One group of sections was immediately inoculated with *C. Pini* by immersion in a spore-emulsion. The remainder were dried for various periods, after which they were inoculated in the same manner. Parallel tests were made with live and dead wood. In the former case drying took place at room temperature; in the latter at 80—90° C.

From the tests it was seen that *C. Pini* developed with different degrees of intensity with different water contents. In the cross-sections with natural water content it was appreciably retarded in its penetration, but already a loss of water of 10 %[1] was sufficient in several instances

[1] Of the cross section's fresh weight.

for obtaining complete blueing of the sapwood even if its exterior, more abundantly watery, annual rings, were less strongly coloured than its interior ones. With a loss of water of 15 % a retardation in the development of the fungus and its capacity of blueing could generally not even be observed in the outer annual rings, but both the inner and outer sapwood was coloured dark-blue equally strongly. The rate of growth of the hyphæ was on an average 5—10 mm. per day, and already after 10—12 days the sapwood portions of the 8 cm. high cross-sections were entirely permeated and discoloured.

With a loss of water of about 20 % the fungus in several cases developed better in the outer than in the inner sapwood, which MÜNCH considers in the first instance to be due to the water content in the inner parts becoming so low that growth was retarded. The smallest water content at which *C. Pini* develops in the timber and causes blueing was, however, not determined.

In February, 1909, MÜNCH (1909, p. 70) carried out a similar series of tests with *Ceratostomella cærulea*, in which he tried to determine the optimal air and water content in the timber for this species. Cross-sections (10—12 cm. high) of pine *(Pinus silvestris)* without heart (22—26 annual rings) were drenched with water or dried in such a manner that a complete series with varied water contents was obtained. After inoculation with conidia of *C. cærulea*, the sections were stored in closed glass vessels for 6 weeks. The results of the tests may be summarised according to MÜNCH (l. c., p. 75) as follows:

»Pine sapwood is perfectly immune against *Ceratostomella cærulea* if the air-space occupies only 15 % of the volume of the fresh wood. This condition is obtained by adding water to an amount of 12 % of the weight of the wood to the wood in winter-condition. With drying of the wood in winter-condition by at least 17 %, through which the air space is raised to 42 % of the wood-volume, the growth of fungus is optimal. Liquid water in the wood is unnecessary for mycelium, the fungus thriving when the walls of the cells contain only water of imbibition. But if also a part of the imbibition water disappears the growth of fungus becomes impossible through lack of water».

2. Method.

In the course of our investigations into the influence of the water content upon the development of blueing fungi in wood we have made use of approximately equally large sectors of slabs of trunk[1] of pine and

[1] Slabs of trunk were cut through radial sections in pieces with sector-shaped crossways surface. These are in the succeeding pages simply called sectors.

spruce. The sectors have been made fairly small so that in the partial removal or addition of water as uniform a water content as possible should be obtained in the sapwood. Their greatest width was 3 cm., and their height about 2,5 cm. After the intended water content had been approximately reached by drenching with water, or drying[1], the sectors (unless otherwise stated) were placed into a thermostat at 50° C, and kept there in closed glass containers for 48 hours. By this means partial sterilisation was obtained, which in most cases was necessary, for the cutting of the sectors, partial drying, drenching with water etc. could not be carried out under aseptic conditions, and furthermore the wood used in quite a number of cases had been felled rather a long time prior to the commencement of the tests, and had therefore already been infected by blueing fungi or other mycelia.

Numerous preliminary tests went to prove that the mycelia and conidia of both blueing fungi and moulds were killed by this process, something that was also confirmed by many later check-tests. While untreated sectors had been severely attacked by *Hormodendrum*, *Penicillium*, *Trichoderma* and other fungi, partially sterilised sectors which had been kept under the same conditions as the former had remained free from visible attack by fungus for several weeks. That wood-destroying *Hymenomycetes* are also killed in damp-saturated air at the said temperature, is proved by SNELL's (1923) investigations. Bacteria possibly occurring in wood do not appear to get killed by this method. But bacteria could nevertheless only rarely be proved to be present in the wood used in the experiments. It was only in tests with wood that had been soaked for a long time (Test-Series 6 & 7) that they occurred to any great extent. They possibly influenced in these experiments the development of the blueing fungi. On the other hand, the advantage of this method of sterilizing is that the conditions in the wood were made very similar to natural conditions.

Complete sterilisation of the sectors — in an autoclave or steam steriliser — has been avoided, because the wood at higher temperatures undergoes very considerable changes. At 50° C, on the other hand, the physical and chemical (including biochemical) structure is probably not very greatly changed.

It was proved by the preliminary tests that the blueing fungi — at least some species — developed much better in partially sterilised, than in autoclave sterilised, wood. An extreme type in this respect is

[1] The addition of water took place at normal room temperature; the partial drying was effected at about 30° C in dry air. In order to reach the lowest degree of moisture used, about 10 hours were required.

Trichosporium tingens, which grows well in the former case, especially in pine timber, but not at all in the latter. The partially sterilised wood is on the other hand somewhat more favourable for the penetration of the fungi than untreated wood. This is probably chiefly due to the fact that in the former competition with the aforesaid infective fungi has been abolished.

After partial sterilisation half the number of sectors were rapidly, one by one, dipped into melted, sterile paraffin (about 90° C), only the tagential surface being left without paraffin. After the paraffin had congealed the dipping process was repeated twice more. This measure was adopted for preventing the air from penetrating from the incision surfaces during the course of the tests. In the preliminary tests no paraffined sectors were used.

The sectors were inoculated with a conidial emulsion or, in those cases where no conidia had developed, with hyphæ. In the former case a central belt along the entire tangential surface was as uniformly as possible covered with the conidial emulsion by means of a platinum loop, in the latter case, the tests with *Xylomyces* I, hyphæ were transplanted to the centre of the tangential surface. Only pure cultures were used as inoculation material. The inoculated sectors were stored at normal temperature in jars of 750 ccm. with a closely fitting lid, or in open, sterilised cups under glass covers.

At the end of the tests examinations were made for contaminations, in which latter case the sectors were rejected.

The sectors were cut into two pieces by a transverse incision, one of the pieces being used for investigating the development of blueing, the other for determining the water content of the sapwood.

The blued portion of the cross-section was sketched and planimetred, and then calculated in percentage of the entire surface of the cross-section.[1] The values thus obtained do not quite exactly express the percentage volume of the blueing in the sector, because the hyphæ may have developed slightly differently in the central portions than in the outer ones. As a rule the values are somewhat too high. But the error will generally probably not exceed 5 %. Other sources of error in the method, caused by minor differences in the length of the sectors, different structure of the wood, and differences in respect of the amount of inoculation material introduced, are also on the whole fairly slight. This condition of things is illustrated by Table 13.

As a matter of course the said percentage figures are quite comparable

[1] In the preliminary tests only the radial extent of the blueing from the tangential surface was measured.

with each other only within one and the same series of tests where sectors from the same wood, consequently with the same diameter and volume of sapwood, have been used. When making a comparison between the extent of the blueing in dissimilar sectors the depth of penetration of the blueing fungi from the tangential surface should preferably be used as a measure. It ought, however, to be pointed out that in this connection not infrequently very erroneous values may be obtained, namely in those cases where the blueing occurs irregularly wedge-shaped in the timber.

As the hyphæ from the inoculated tangential surface penetrate chiefly in a radial direction into the pith-rays, both the percentage figure of the blueing and its radial extent is a sign of the growth of the blueing fungi in the wood.

The intensity of colour in the blueing has been shown by a treble-graded scale (X—XXX).

The water content was determined, unless otherwise indicated, in the outer 20 mm. of the sapwood. From the half-sector intended for determining the water a cubical piece 20 mm. wide and 20 mm. deep was cut, which was dried at 100° C. The water content was expressed both in percentage of the dry substance (I) and in percentage of the water-capacity[1] (II). The water content expressed in the latter manner may appropriately be designated according to KINNMAN (1925, p. 21) as the degree of saturation of the timber. It was found necessary to determine the water content in each sector, inasmuch as the same varied quite considerably in sectors that had been dried for the same length of time.

The material used for investigation consisted not only of timber with primarily free water but also of timber with secondarily free water. The latter timber was after felling cut into sectors and air-dried. After 6 months storage in a dry place it was placed in water for 2 months, the water usually being changed every third day. The reason for doing this was to ascertain whether the fungi behaved differently in fresh timber than in timber that had once been air-dried.

The timber came from Lidingön (near Stockholm).

The following species were used for the pine experiments:

1) *Ceratostomella cærulea*
2) » *Pini*
3) *Discula pinicola* v. *mammosa*
4) *Hormonema dematioides*
5) *Trichosporium tingens*
6) *Hormodendrum cladosporioides*
7) *Leptographium Lundbergii*
8) *Alternaria humicola*

[1] The water-capacity was determined in freshly felled timber.

and for the spruce experiments:

1) *Ceratostomella Piceæ*
2) *Endoconidiophora cœrulescens*
3) *Hormonema dematioides*
4) *Xylomyces* I.

3. Investigations into timber with primarily free water.

In the preliminary or orientation tests only non-paraffined sectors were used. No partial sterilisation was effected. For this reason a large number of sectors had to be rejected owing to air-infection.

Test Series 1. Trial tests with freshly-felled pine and spruce. The trees were felled on the 3rd April, 1924; the trials commenced 4 days later. In respect of reserve nutrition, the trees were still in their winter-stage.

The section of pine used was 35-years old with a diameter of 18,5 cm. The sapwood occupied about 95 % of the volume. The width of the rings in the sapwood was on the average 2,6 mm. Water content of the sapwood (I) in the freshly-felled timber 148 %. Degree of saturation (II) 81 %.

The section of spruce had 35 rings and a diameter of 17 cm. The sapwood occupied about 80 % of the volume. Width of ring in sapwood 2,8 mm. Water content of sapwood (1) 146 %; degree of saturation (II) 71 %.

The original idea was to expose the sectors after inoculation to different relative moisture in different glass covers. It was, however, very soon discovered that by means of the method used the relative moisture in the covers could be reduced only slightly, thanks to the high water content in the wood. One cover was therefore removed 15 hours after the sectors had been inoculated, and the latter subjected to direct drying in the laboratory which had a relative average air-moisture of 35 %. After 4 days the cover was once more put on. Renewed inoculation of the sectors referred to was not resorted to.

The pine sectors were inoculated with *Ceratostomella cœrulea* and *Trichosporium tingens*, the spruce sectors with *Endoconidiophora cœrulescens*. A summary of the most important results has been drawn up in Table 1.

Table 1. **Trial tests with *Ceratostomella cœrulea*, *Trichosporium tingens* and *Endoconidiophora cœrulescens* on wood of different water contents.**
Försök med *Ceratostomella cœrulea*, *Trichosporium tingens* och *Endoconidiophora cœrulescens* vid olika vattenhalt i virket.

Tests with Försök med	The water content of the sapwood at the end of the test was Splintens vattenhalt vid försökets slut var		After 17 days blueing Efter 17 dagar blånad		After 30 days blueing Efter 30 dagar blånad		Notes Anmärkningar
	I %	of original water content [1] av ursprunglig % vattenhalt	Depth [2] Djup mm	Intensity of colour Färgens intensitet	Depth [2] Djup mm	Intensity af colour Färgens intensitet	
Ceratostomella cœrulea on pine.	148	100	1—5	0—X	20—25	X	Blueing in centre slight, has reached greatest depth along incision surfaces. Blånad svag i centrum, harnått största djupet längs snittytorna.
	130	88	9	XXX	—	—	Blueing uniformly distributed in outer sapwood. Blånaden likformigt fördelad i yttre splinten.
	35	24	0—5	X	0—15	X	Blueing only in central portions of outer sapwood. Blånad endast i de centrala delarna av yttre splinten.
Trichosporium tingens on pine.	145	100	0—0,5	0—X	—	—	
	130	88	0—16	XXX	0—35	XXX	Blueing irregularly wedge-shaped. Blånad oregelbundet kilformad.
Endoconidiophora cœrulescens on spruce.	146	100	43	XXX	—	—	Blueing more intense along incision surfaces than in centre. Blånaden mera intensiv längs snittytorna än i centrum.
	111	76	60	XXX	—	—	Blueing uniformly distributed in central portions and along incision surfaces. Blånad likformigt fördelad i de centrala delarna och längs snittytorna.
	25	17	0	0	—	—	

[1]) Water content in sapwood of freshly felled timber.
[2]) Reckoned from tangential surface.

It will be seen that *Ceratostomella cærulea* and *Trichosporium tingens* with a natural water content in the sapwood (148 % of the dry substance) had been greatly retarded in their growth, which was also, although to a lesser degree, the case with *Endoconidiophora*. The fungi developed, however, with a high water content much more strongly along the incision surfaces than in the centre, which has also been pointed out by MÜNCH. This condition therefore seemed to confirm this investigator's theory, that it is primarily the lack of oxygen which retards the development of the fungi when the water content in the sapwood is high.

Partial drying of the sapwood affected the growth of the fungi very favourably. The optimal water content could, however, not be determined by this test. Nor was the lower limit for growth ascertained. With 35 % water content (I) *Ceratostomella cærulea* still caused distinct blueing which was, however, restricted to the centre of the sector. No conidia of *Endoconidiophora cærulescens* could germinate at 25 % water content (I).

Test Series 2. Trial tests with pine and spruce timber (broad-ringed). Parallels were drawn between tests with timber felled on the 3rd April, 1924 (*a*) and in January, 1924 (*b*). The first mentioned came from the same trees as the timber in Series 1.

The nature of the timber will be apparent from Table 2.

Table 2. **Timber used in test series 2.**
Det i försöksserien 2 använda virket.

	Diam. cm	Age years Ålder år	Sapwood mm. Splint mm	Width of annual ring in sapwood mm. Årsringsbredd i splinten mm	Water content (I) of sapwood % Vattenhalt i splinten
Pine Tall *a*	16	31	50—55	2,6	148
b	15	28	50	2,7	155
Spruce Gran *a*	17	32	50	2,8	146
b	20	34	50	2,9	127

Ceratostomella cærulea and *Endoconidiophora cærulescens* were used for the inoculations.

The test was commenced on the 16th May, 1924, and went on for one month.

Table 3. **Trial tests with *Ceratostomella cœrulea* and *Endoconidiophora cœrulescens*. Trees felled: *a* on the 3rd April, 1924, *b* in January, 1924. Test-period one month.**

Försök med *Ceratostomella cœrulea* och *Endoconidiophora cœrulescens*. Träden avverkade *a* den 3:e april 1924, *b* i januari 1924. Försökstid en månad.

Tests with Försök med	Nature of timber Trädslag	Water content of sapwood Splintens vattenhalt		Blueing Blånad		Notes Anmärkningar
		I %	original water content[1] % av ursprunglig vattenhalt	Depth mm. Djup mm	Intensity of colour Färgens intensitet	
Ceratostomella cœrulea	Pine *a* Tall	119	79	50	XXX	Blueing uniformly distributed in centre of sapwood and along incision surfaces.
	»	88	59	55	XXX	
	»	41	27	45	XXX	Blånad likformigt fördelad i splintens centrum och längs snittytorna.
	»	32	21	20	XX	Blueing concentrated to central portions of sector. Blånad koncentrerad till de centrala delarna av sektorn.
	Pine *b* Tall	155	100	25	X	Blueing more pronounced along incision surfaces than in centre. Blånad mera intensiv längs snittytorna än i centrum.
	»	140	90	40	XXX	
	»	120	77	50	XXX	Blueing uniformly distributed.
	»	101	65	45	XXX	
	»	69	45	50	XXX	Blånad likformigt fördelad.
	»	43	28	45	XXX	
	»	22	14	0	0	The conidia have not germinated. Konidierna ha ej grott.
Endoconidiophora cœrulescens	Spruce *a* Gran	100	68	50	XXX	Blueing uniformly distributed.
	»	90	62	50	XXX	Blånad likformigt fördelad.
	»	31	21	0	0	The conidia have not germinated. Konidierna ha ej grott.
	Spruce *b* Gran	127	100	35	X	Blueing more pronounced along incision surfaces than in centre. Blånad mera intensiv längs snittytorna än i centrum.
	»	120	94	50	XXX	
	»	100	79	50	XXX	Blueing uniformly distributed.
	»	91	72	50	XXX	
	»	40	31	35	XXX	Blånad likformigt fördelad.
	»	34	27	0	0	The conidia have not germinated. Konidierna ha ej grott.
	Pine *a* ... Tall	120	80	50	XXX	
		90	60	50	XXX	

[1] Reckoned from tangential surface.

From Table 3, where the most important results are summarised, it will be seen that *Ceratostomella cœrulea* and *Endoconidiophora cœrulescens* behaved in the same manner in *a* and *b*. With a 10 % loss of water both species reached an optimal development, inasmuch as the entire sapwood was permeated and stained. The rate of growth remains approximately constant with a reduced water content, as far as 40 % water content (I), when it rapidly diminishes.

With a natural water content the growth was retarded in the same way as in previous tests. This was especially the case in the central portions of the sectors where rather frequently no discoloration could be observed, while the same was pronounced close to the incision surfaces. Because of this it was obvious that by the method employed

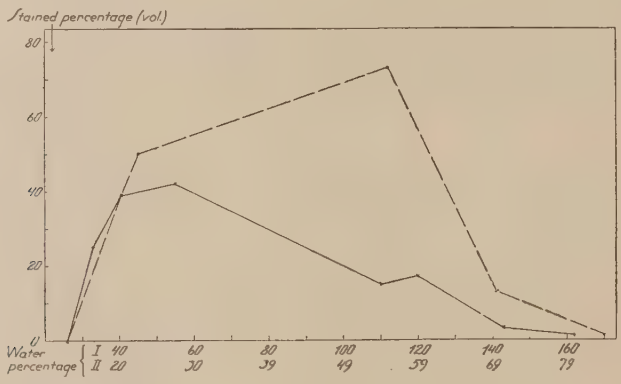


Fig. 70. Blueing by *Ceratostomella cœrulea* in broad-ringed, winter-felled pine with different water contents. Paraffined (——) and non-paraffined (- - -) sectors.
Blånad av *Ceratostomella cœrulea* i frodvuxen, vinterfälld tall vid olika vattenhalt. Paraffinerade och ej paraffinerade (- - - -) sektorer.

it was impossible to obtain results that could be directly adapted to the conditions prevalent in round timber.

In the ensuing tests the method was therefore modified in so far that parallel tests were made with paraffined and non-paraffined sectors in the aforesaid manner.

Furthermore the sectors were partially sterilised.

Test Series 3. Pine-wood (broad-ringed) with various water contents.

The pines were felled on the 27th October, 1924. The test commenced on the 4th November of the same year and lasted for three weeks.

The sectors were taken from the middle portion of the trunk where the diameter was 14 cm. (inside bark) and the age 25 years. The sapwood was about 60 mm. thick, containing 21 rings (about 95 % of the volume). Width of ring in sapwood 2,8 mm.

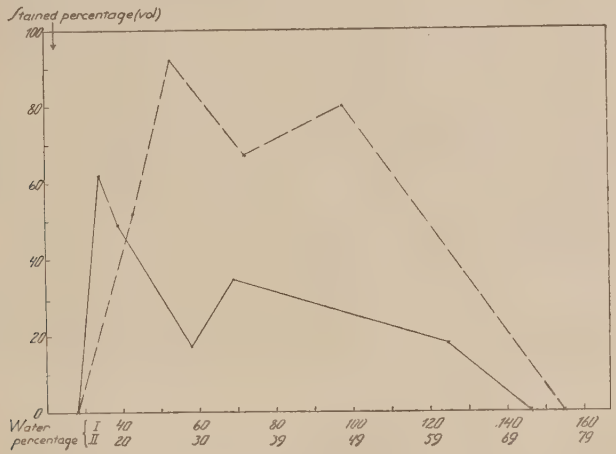


Fig. 71. Blueing of *Discula pinicola* v. *mammosa* in broad-ringed, winter-felled pine with different water contents. Paraffined (——) and non-paraffined (- - -) sectors.

Blånad av *Discula pinicola* v. *mammosa* i frodvuxen, vinterfälld tall vid olika vattenhalt. Paraffinerade (——) och e paraffinerade (- - -) sektorer.

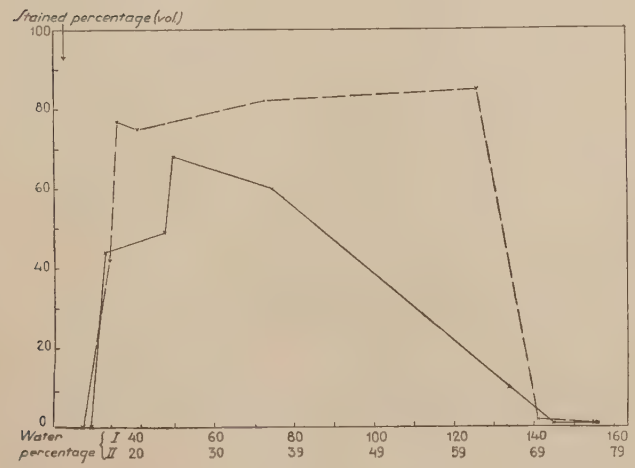


Fig. 72. Blueing by *Trichosporium tingens* in broad-ringed, winter-felled pine with different water contents. Paraffined (——) and non-paraffined (- - -) sectors.

Blånad av *Trichosporium tingens* i frodvuxen, vinterfälld tall vid olika vattenhalt. Paraffinerade (— —) och ej paraffinerade (- - -) sektorer.

The water content (I) was 145 % in the outer sapwood, 152 % in the inner sapwood, and 44 % in the heart.

The degree of saturation in the outer sapwood was 70 %.

The species used were:

Ceratostomella cœrulea, *Discula pinicola* v. *mammosa*, *Trichosporium tingens* and *Leptographium Lundbergii*.

The results are given in Table 4 and fig. 70—73. It will be seen that the four species investigated behaved on the whole in the same way.

In respect of the paraffined sectors, the blueing was extremely slight in the tests with natural water content (about 70 % II, 145 % I).

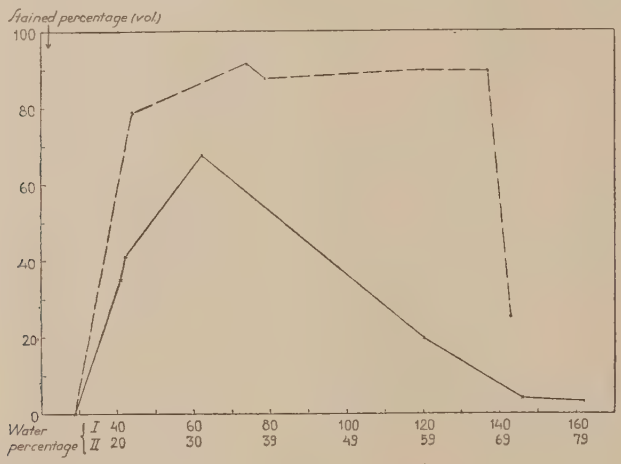


Fig. 73. Blueing by *Leptographium Lundbergii* in broad-ringed, winter-felled pine with different water contents. Paraffined (——) and non-paraffined (- - - -) sectors.

Blånad av *Lepthographium Lundbergii* i frodvuxen, vinterfälld tall vid olika vattenhalt. Paraffinerade (— —) och ej paraffinerade (- - - -) sektorer.

The hyphæ had penetrated from the tangential surface at the most 2 mm. and caused only a very faint, partly hardly noticeable stain.

The growth was on the whole the same where the water content in the sapwood was augmented by 7—12 % of the original, i. e. to 76—79 % degree of saturation. The upper water content at which the hyphæ no longer were able to penetrate into the sapwood, was not determined.

Partial drying affects the penetration of the fungi favourably. As will be seen from fig. 70—73, the curves for the speed with which the fungi blue the wood with a reduced water content have an evenly rising

course until the optimal water content is reached. This latter is not the same for the different species. In the test it was for:

	I	II
Ceratostomella cœrulea	55 %	27 %
Discula pinicola v. *mammosa*	34 %	17 %
Trichosporium tingens	50 %	24 %
Leptographium Lundbergii	62 %	30 %

From their maximum the curves drop more or less rapidly. With a water content (I) of 33 % in the sapwood *Ceratostomella cœrulea* and *Trichosporium tingens* still developed fairly well and caused intense blueing; with 23—29 % of water content (I) the conidia could, however, not germinate, and blueing had remained entirely absent. The curve for *Discula pinicola* drops from its maximum at 34 % water content (I) almost perpendicularly with a reduced water content; that for *Leptographium Lundbergii* slightly less rapidly between 62 and 28 % water content (I)[1].

In the non-paraffined sectors the fungi behaved differently. With a natural water content only *Discula pinicola* and *Trichosporium tingens* have been strongly retarded or prevented from penetrating the sapwood, while *Ceratostomella cœrulea* and *Leptographium Lundbergii* have caused blueing of respectively 13 and 25 % of the sectors. Of the latter two species only *C. cœrulea* has been investigated in its relation to a higher water content than the natural one, viz. 83 % degree of saturation (171 % water content I), at which hyphæ had been able to penetrate only about 1 mm. from the surface, causing a hardly noticeable discoloration.

Only a slight loss of water (about 10 % of the natural content) is enough for the fungi to reach an optimal development. *Leptographium* and *Trichosporium* thus showed with a loss of water of 6 and 13 % (degree of saturation 67 and 61 % water content I 137 and 126 %), a blueing percentage of 96 and 95 % respectively. At least in these two species curves for the blueing rapidity have a horizontal course until about 40 % water content I (about 20 % degree of saturation), whence they drop almost perpendicularly. With 25—27 % water content (I) the conidia have not germinated. The curves for *Ceratostomella cœrulea* and *Discula pinicola* have on the whole the same course. With a water content (I) of about 45 % (about 22 % degree of saturation) the curves drop rapidly; with 27 % water content (I) *C. cœrulea* has penetrated

[1] In test-series 9 (Table 12) with spring-felled, broad-ringed pine *Leptographium Lundbergii* has developed still strongly with a water content of 30 % (I).

Table 4. **Blueing of pine (broad-ringed) with different water contents. The pine was felled on the 27th October, 1924. The tests commenced on the 4th November of the same year. Test-period three weeks. Normal room temperature.**

Blånad å tall (frodvuxen) med olika vattenhalt. Tallen avverkades den 27 oktober 1924. Försöket började den 4 november samma år. Försökstid tre veckor. Rumstemperatur.

Fungus Svamp	No.	Paraffined sectors Sektorerna paraffinerade					Non-paraffined sectors Sektorerna ej paraffinerade				
		Water content Vattenhalt			Blueing Blånad		Water content Vattenhalt			Blueing Blånad	
		I %	II %	of original water content % av den ursprungliga %	in % of sector av sektorn %	colour färg	I %	II %	of original water content % av den ursprungliga %	in % of sector av sektorn %	colour färg
Ceratostomella cærulea.	1	162	79	112	1	o—X	171	83	118	1[2]	o—X
	2	143[1]	70	100	3	X	141	69	100	73	X
	3	120	59	83	17	XXX	112	55	77	74	XXX
	4	110	54	76	15	XXX	45	22	31	49	XXX
	5	55	27	38	42	XXX	45	22	31	51	XXX
	6	40	20	27	39	XX-XXX	44	21	30	50	XXX
	7	33	16	23	25	XX-XXX	27	13	19	1[3]	X
	8	23	11	16	o	o	22	11	15	o	o
Discula pinicola v. *mammosa*	1	161	69	111	4	X	155	76	100	o	o
	2	146[1]	71	100	o	o	98	48	68	81	XXX
	3	124	60	86	19	XXX	72	35	50	67	XXX
	4	69	34	48	35	XXX	53	26	37	92	XXX
	5	58	28	40	18	XXX	43	21	30	52	XXX
	6	39	19	27	50	XXX	28	14	19	o	o
	7	34	17	23	62	XXX	—	—	—	—	—
	8	26	13	18	o	o	—	—	—	—	—
Trichosporium tingens	1	155	76	107	1	X	156	76	108	1[2]	X
	2	145[1]	71	100	1	X	141	69	100	2	X
	3	134	65	92	10	XXX	126	61	87	85	XXX
	4	75	36	52	60	XXX	73	36	50	82	XXX
	5	50	24	34	68	XXX	41	20	28	75	XXX
	6	48	23	33	49	XXX	36	18	25	77	XXX
	7	33	16	23	44	XXX	34	17	23	42	XXX
	8	29	14	20	o	o	27	13	19	o	o
Leptographium Lundbergii	1	162	79	112	3	X	143	70	100	25	XX
	2	146[1]	71	100	5	X	137	67	94	96	XXX
	3	120	59	83	19	XXX	120	59	83	96	XXX
	4	62	30	43	67	XXX	78	38	54	94	XXX
	5	42	20	29	41	XXX	74	36	51	98	XXX
	6	41	20	28	35	XXX	44	21	30	79	XX
	7	28	14	19	o	o	25	12	17	o	o
	8	26	13	18	o	o	—	—	—	—	—

[1] Sectors not partially sterilised.
[2] Besides blueing in inner portion of sapwood.
[3] Mycelium covering about 1/3 of tangential surface.

1—2 mm. (the mycelium covers about $^1/_3$ of the tangential surface), whereas *Discula* at 28 % water content (I) has not grown.

The most important difference in regard to the behaviour of the fungi in non-paraffined and paraffined sectors with different water contents has therefore been, that in the former case with a loss of water of 6—13 % they have already reached their development and blueing optimum, whereas in the latter instance this was first reached with a loss of water of 57—77 %. In the former case the fungi have a broad optimal zone, from about 62—67 % degree of saturation (125—135 % water content I) — *Leptographium* and *Trichosporium* — to about 20 % degree of saturation (40 % water content I); in the latter, on the other hand, they have a

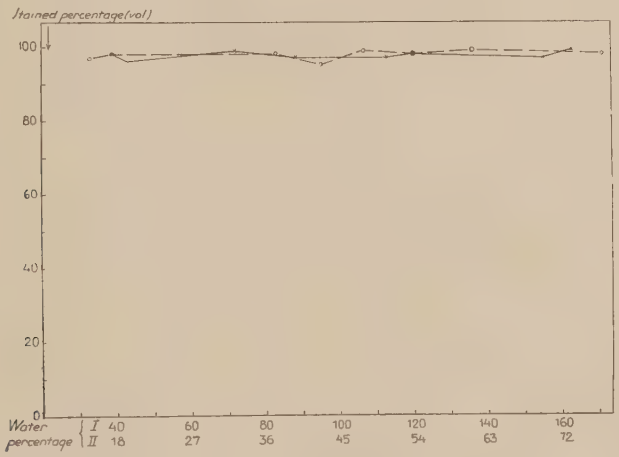


Fig. 74. Blueing by *Ceratostomella Pini* in broad-ringed, winter-felled pine with different water contents. Paraffined (——) and non-paraffined (- - -) sectors.

Blånad av *Ceratostomella Pini* i frodvuxen, vinterfälld tall vid olika vattenhalt. Paraffinerade (— —) och ej paraffinerade (- - -) sektorer.

more sharply restricted optimum at about 17—30 % degree of saturation (34—62 % water content I).

As an important difference it may further be pointed out that the fungi when developing optimally display a more rapid growth in non-paraffined than in paraffined sectors, which finds expression in the fact that the percentage of blueing is maximally much greater in the former than in the latter (fig. 70—73).

Test-Series 4. Pine-timber, broad-ringed, with different water contents. The pine was felled on the 8th December 1925; the tests commenced on the 30th March, 1926, and lasted three weeks.

The section used was 14 cm. in diameter and had 30 rings. Heart was absent. Width of rings in sapwood on the average 2,2 mm.

The water content was in:

	I	II
outer sapwood	175 %	79 %
inner sapwood	162 %	71 %

The species used were:

Ceratostomella Pini, *Hormonema dematioides*, *Hormodendrum cladosporioides* and *Alternaria humicola*.

The results are given in Table 5 and fig. 74—77.

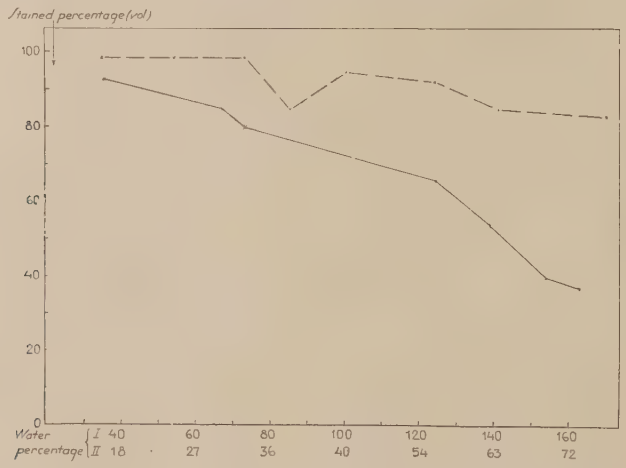


Fig. 75. Blueing by *Hormonema dematioides* in broad-ringed, winter-felled pine with different water contents. Paraffined (——) and non-paraffined (- - - -) sectors.

Blånad av *Hormonema dematioides* i frodvuxen, vinterfälld tall vid olika vattenhalt. Paraffinerade (— —) och ej paraffinerade (- - - -) sektorer.

We find that *Ceratostomella Pini* represents a type deviating from the remaining species (fig. 74). In both paraffined and non-paraffined sectors the growth-curves have already reached their maximal position at 73—77 % degree of saturation (163—171 % water content I), and then run parallel with a reduced water content until at least 36 % water content (I). How the fungus behaves with a natural water content in the wood (79 % degree of saturation, 175 water content I), could not be ascertained, inasmuch as the sectors in the partial drying in this test parted with some of their water. It is worthy of note that the blueing-speed is equally great in paraffined and non-paraffined sectors, in contradistinction to what is the case in the other species investigated. This feature will be further treated later on.

Hormonema dematioides (fig. 75) has already developed fairly strongly at 73 % degree of saturation (163 % water content I) in paraffined sectors. Hence the curve rises almost in a straight line to 35 % water con-

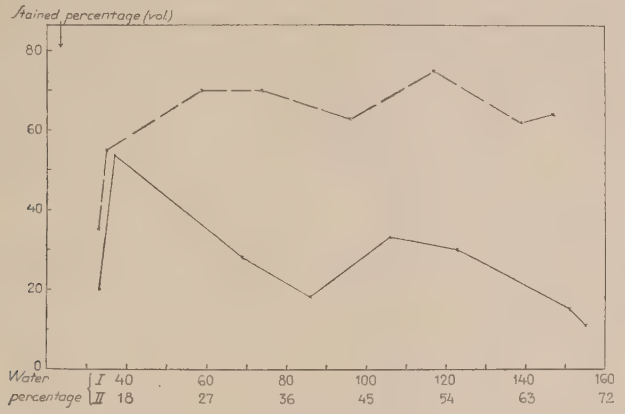


Fig. 76. Blueing by *Hormodendrum cladosporioides* in broad-ringed, winter-felled pine with different water contents. Paraffined (——) and non-paraffined (- - - -) sectors.

Blånad av *Hormodendrum cladosporioides* i frodvuxen, vinterfälld tall vid olika vattenhalt. Paraffinerade (— —) och ej paraffinerade (- - - -) sektorer.

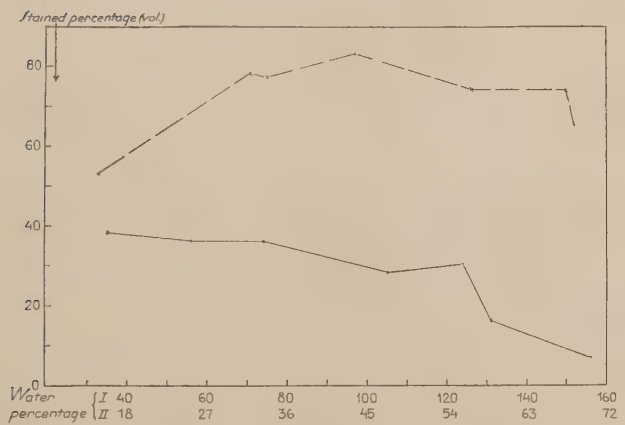


Fig. 77. Blueing by *Alternaria humicola* in broad-ringed, winter-felled pine with different water contents. Paraffined (——) and non-paraffined (- - - -) sectors.

Blånad av *Alternaria humicola* i frodvuxen, vinterfälld tall vid olika vattenhalt. Paraffinerade (— —) och ej paraffinerade (- - - -) sektorer.

tent (I) (16 % degree of saturation), whence it probably drops rapidly. In non-paraffined sectors the development at 76 % degree of saturation (170 % water content I) is very strong and the growth-curve with a reduced

water content takes an approximately parallel course until about 35 % water content I (16 % II).[1]

Table 5. **Blueing of pine (broad-ringed) with different water contents. The pine was felled on the 8th December, 1925, the tests commenced on the 30th March, 1926. Test-period three weeks. Normal room temperature.**

Blånad å tall (frodvuxen) med olika vattenhalt. Tallen avverkades den 8 december 1925. Försöket började den 30 mars 1926. Försökstid 3 veckor. Rumstemperatur.

Fungus Svamp	No.	Paraffined sectors Sektorerna paraffinerade					Non-paraffined sectors Sektorerna ej paraffinerade				
		Water content Vattenhalt			Blueing Blånad		Water content Vattenhalt			Blueing Blånad	
		I %	II %	of original water content % av den ursprungliga	of sector % av sektorn %	colour färg	I %	II %	of original water content % av den ursprungliga	of sector % av sektorn %	colour färg
Ceratostomella Pini	1	163	73	93	96	XX	171	77	98	98	XX
	2	155	70	89	97	XX	136	61	78	99	XXX
	3	120	54	69	98	XXX	120	54	69	98	XXX
	4	113	51	65	97	XXX	107	48	61	99	XXX
	5	88	39	50	97	XXX	95	43	54	95	XXX
	6	72	32	41	99	XXX	83	37	47	98	XXX
	7	43	19	25	96	XXX	39	18	22	98	XXX
	8	39	18	22	98	XXX	36	16	21	97	XXX
Hormonema dematioides	1	163	73	93	37	X	170	76	97	83	XXX
	2	154	69	88	40	X	141	64	81	85	XXX
	3	139	62	80	54	XXX	124	56	71	92	XXX
	4	124	56	71	66	XXX	100	45	57	95	XXX
	5	73	33	42	80	XXX	85	38	49	85	XXX
	6	67	30	38	85	XXX	73	33	42	99	XXX
	7	35	16	20	93	XXX	54	24	31	99	XXX
	8	—	—	—	—	—	34	15	19	99	XXX
Hormodendrum cladosporioides	1	155	70	89	11	XXX	147	66	84	64	XXX
	2	151	68	86	15	XXX	139	63	80	62	XXX
	3	123	55	70	30	XXX	117	53	67	75	XXX
	4	105	48	61	33	XXX	96	43	55	63	XXX
	5	86	39	49	18	XXX	74	33	42	70	XXX
	6	69	31	39	28	XXX	59	26	34	70	XXX
	7	37	17	21	54	XXX	35	16	20	55	XX
	8	33	15	19	20	X	33	15	19	35	X
Alternaria humicola	1	157	71	90	6	XX	152	68	87	65	XX
	2	131	59	75	16	XXX	150	67	86	74	XXX
	3	124	56	71	30	XXX	126	57	72	74	XXX
	4	105	47	60	28	XXX	97	43	55	83	XXX
	5	74	33	42	36	XX	77	35	44	77	XXX
	6	56	25	32	36	X	71	32	41	78	X
	7	35	16	20	38	X	33	15	19	53	X

[1] In Test-Series 9 (Table 12) with spring-felled, broad-ringed pine *Hormonema dematioides* still showed optimal growth with a water content of 32 %.

The curves for *Hormodendrum cladosporioides* (fig. 76) and *Alternaria humicola* (fig. 77) take on the whole the same course. In the paraffined sectors the growth is nevertheless fairly insignificant at 70 % degree of saturation (150 % water content I); it increases successively when the water content is reduced to about 35 % I (16 % II), after which it diminishes rapidly (*Homodendrum*). In non-paraffined sectors the curves at 66 % degree of saturation (147 % water content I) have reached their maximum and proceed on the whole parallel until about 35 % water content (I) (16 % II).

Test-Series 5. Spruce timber (fairly close-ringed) with different water contents. The tree was felled on the 27th October, 1924; the test commenced on the 4th November of the same year. Test-period three weeks.

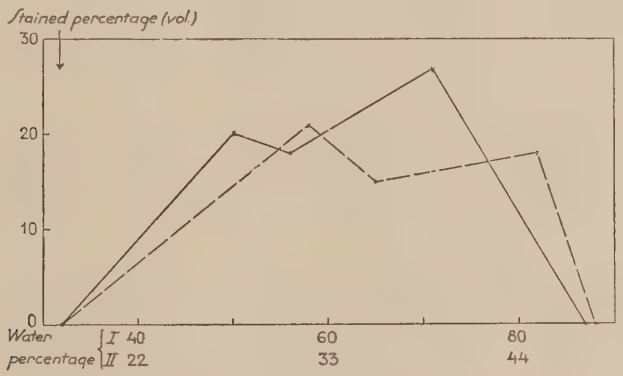


Fig. 78. Blueing by *Hormonema dematioides* in close-ringed, winter-felled spruce with different water contents. Paraffined (——) and non-paraffined (- - - -) sectors.
Blånad av *Hormonema dematioides* i senvuxen, vinterfälld gran vid olika vattenhalt. Paraffinerade (——) och ej paraffinerade (- - - -) sektorer.

The sectors were taken from the middle of the trunk, which had a diameter of 14 cm. and 71 rings. The sapwood was 3,3 cm. thick, embracing 35 rings (about 70 % of the sectors). Width of rings in sapwood on the average 0,9 mm.

The water content in sapwood was 80—96 % (I), 40—50 % (II).

The species used were: *Ceratostomella Piceæ*, *Endoconidiophora cœrulescens*, *Hormonema dematioides* and *Xylomyces* I.

The results are summarised in Table 6 and fig. 78—79. It will be seen that the four species investigated did not behave in the same manner. *Ceratostomella Piceæ* deviates from the others in such a way that it

practically has not caused any blueing of the wood. Although in all sectors to a water content (I) of 31—35 % it had developed well on the surface (abundance of graphia; solitary, undeveloped perithecia), only in one or two instances, viz. at about 60 % water content (I), a faintly blue-green colour could be discovered in the two outermost rings. In the remaining cases the hyphæ had certainly penetrated into the wood, but not brought about any discoloration. At 26 % water content (I) (14 % II) the conidia had germinated but developed only very small, languishing colonies which lacked graphia; at 24 % water content (I) no germination had taken place.

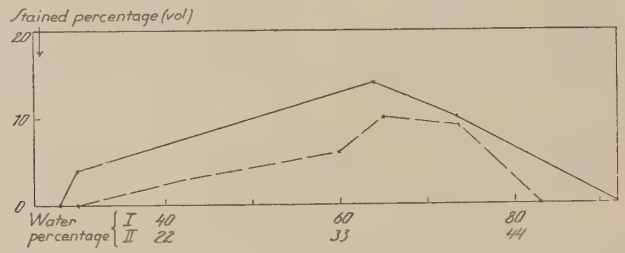


Fig. 79. Blueing by *Xylomyces* I in close-ringed, winter-felled spruce whit different water contents. Paraffined (——) and non-paraffined (- - - -) sectors.

Blånad av *Xylomyces* I i senvuxen, vinterfälld gran vid olika vattenhalt. Paraffinerade (——) och ej paraffinerade (- - - -) sektorer.

The other species caused blueing when the sectors were partially dried, although this in comparison with previous tests was fairly insignificant both in extent and intensity. The fungi developed in approximately the same manner, no matter whether the sectors were paraffined or not. With a natural water content (47 % II, 85 % I) no noticeable colouring of the sapwood took place, although hyphæ could be found to be present in the pith-rays of the outer rings. The optimal zone of growth for the fungi was rather small and had about the same limitation in paraffined and non-paraffined sectors. For *Endoconidiophora cœrulescens* it was between about 42 and 33 % degree of saturation (about 75 and 60 % water content I); for *Hormonema dematioides* (fig. 78) and *Xylomyces* I (fig. 79) between about 44 and 28 % degree of saturation (about 80 and 50 % water content I).

The lower limit for the blueing capacity was for *Endoconidiophora* at about 40 % water content (I); for *Hormonema* and *Xylomyces* I at about 30 % or slightly higher. At 27 % water content I (15 % II) the conidia of the two last-mentioned species germinated but developed only very small, colourless colonies upon the tangential surface.

Table 6. **Blueing of spruce (fairly close-ringed) with different water contents. The tree was felled on the 27th October, 1924; the tests commenced on the 4th November of the same year. Test-period three weeks. Normal room temperature.**

Blånad i gran (tämligen senvuxen) med olika vattenhalt. Träden avverkades den 27 oktober 1924; försöken började den 4 november samma år. Försökstid tre veckor. Rumstemperatur.

Fungus Svamp	No.	Paraffined sectors Sektorerna paraffinerade					Non-paraffined sectors Sektorerna ej paraffinerade				
		Water content Vattenhalt			Blueing Blånad		Water content Vattenhalt			Blueing Blånad	
		I %	II %	of original water content % av den ursprungliga	in % of sector av sektorn %	colour färg	I %	II %	of original water content % av den ursprungliga	in % of sector av sektorn %	colour färg
Endoconidiophora cærulescens	1	74	41	87	46	o—X	85	47	100	0	o
	2	68	38	80	46	X	61	34	72	46	X
	3	57	32	67	38	XX	43	24	51	3	X
	4	27	15	32	0	o	40	22	47	0	o
	5	—	—	—	—	—	28	16	33	0	o
Hormonema dematioides	1	87	48	100	0	o	88	49	100	0	o
	2	71	39	84	27	X	82	46	96	18	X
	3	56	31	66	18	X	64	36	75	15	X
	4	50	28	59	20	X	58	32	68	21	X
	5	32	18	38	0[1]	o	30	17	35	0[1]	o
	6	27	15	32	0[1]	o	29	16	34	0[1]	o
Xylomyces I	1	92	51	100	0	o	83	46	100	0	o
	2	75	42	88	11	X	73	41	86	9	X
	3	74	41	87	10	X	72	40	85	9	X
	4	64	36	75	14	X	65	36	76	10	X
	5	47	26	55	8	XX	60	33	71	6	XX
	6	30	17	35	4	XX	43	24	51	3	XX
	7	28	16	33	0[1]	o	30	17	35	< 1	X
	8	27	15	32	0[1]	o	28	16	33	0[1]	o
Ceratostomella Piceæ	1	80	44	100	0	o	83	46	100	0	o
	2	80	44	100	0	o	74	41	87	0	o
	3	76	42	89	0	o	72	40	85	0	o
	4	66	37	78	< 1	X	56	31	66	< 1	X
	5	35	19	41	0	o	31	17	36	0	o
	6	26	14	31	0[1]	o	27	25	32	0[1]	o

4) Investigations into timber with secondarily free water.

Test-Series 6. Pine timber (broad-ringed) with various water contents. The pine was felled on the 3rd April, 1924; the tests commenced on the 13th December, 1924. Test-period 30 days.

[1] The conidia or hyphæ have developed and formed small colonies on the tangential surfaces.

The timber came from the same tree as that used for test-series 1 and 2 (*a*).

The sectors were taken from the very middle of the trunk, which measured 15 cm. in diameter and had 30 rings. The sapwood was 6 cm. thick; width of rings in sapwood 2,7 mm.

Table 7. **Blueing of pine (broad-ringed) with different water contents. The pine was felled on the 3rd April, 1924. The sectors were air-dried during the summer, after which they were immersed in water. The tests commenced on the 15th December, 1924. Test-period 30 days. Normal room temperature.**

Blånad å tall (frodvuxen) med olika vattenhalt. Träden avverkades den 3:e april 1924. Sektorerna lufttorkades under sommaren, varefter de förvarats nedsänkta i vatten. Försöken började den 13 december 1924. Försökstid 30 dagar. Rumstemperatur.

Fungus Svamp	No.	Paraffined sectors Sektorerna paraffinerade					Non-paraffined sectors Sektorerna ej paraffinerade				
		Water content Vattenhalt			Blueing Blånad		Water content Vattenhalt			Blueing Blånad	
		I %	II %	of original water content % av den ursprungliga	in % of sector av sektorn %	colour färg	I %	II %	of original water content % av den ursprungliga	in % of sector av sektorn %	colour färg
Ceratostomella cærulea[1]	1	101	56	65	13	o—X	108	60	70	36	o—X
	2	100	55	65	11	o—X	93	51	60	42	o—X
	3	83	46	54	33	o—X	65	36	42	41	o—X
	4	66	36	43	25	o—X	60	33	39	25	o—X
	5	24	13	15	o[2]	o	15	8	10	o	o
Discula pinicola v. *mammosa*	1	115	63	74	8	XXX	128	70	83	58	XXX
	2	107	59	69	13	XXX	98	54	63	58	XXX
	3	83	46	54	65	XXX	83	46	54	57	XXX
	4	83	46	54	60	XXX	73	40	47	69	XXX
	5	36	20	23	78	XXX	32	18	21	92	XXX
	6	23	13	15	o	o	24	13	15	o	o
Trichosporium tingens	1	114	63	74	3[3]	X	100	55	65	1[3]	X
	2	87	48	56	14[3]	XX	95	52	61	8[3]	XX
	3	72	40	46	4[3]	XX	73	40	47	9[3]	XX
	4	28	15	18	o	o	36	20	23	o	o
	5	26	14	17	o	o	25	14	16	o	o
Leptographium Lundbergii	1	100	55	65	88	XX	88	48	57	90	XX
	2	82	45	53	90	XX	83	46	54	89	XX
	3	63	35	41	33	XX	75	41	48	87	XX
	4	28	15	18	o	o	62	34	40	88	XX
	5	21	12	14	o	o	27	15	17	o	o
	6	18	10	12	o	o	20	11	13	o	o

[1] Blueing hardly noticeable.

[2] The conidia have formed a light-grey mycelium (20 × 10 mm.) on the tangential surface.

[3] The hyphæ have penetrated in narrow streaks along the tangential surface, giving to the blued portions in cross-section the form of ray-shaped wedges.

The water content (I) in the sapwood of the freshly felled timber was 155 %; water capacity, 182 %.

The sectors were allowed to dry in the air, and were kept in a dry place until the beginning of October, when they were immersed in water. The water was changed as a rule every third day, and after about two months partial drying was effected, one series of sectors was not dried, after which the sectors were treated as in previous tests.

The species tested were: *Ceratostomella cœrulea*, *Discula pinicola* v. *mammosa*, *Trichosporium tingens*, *Leptographium Lundbergii*.

The results are given in Table 7 and fig. 80—82.

Of the four species, *Trichosporium tingens* and *Ceratostomella cœrulea* developed most poorly. They caused only slight blueing. The former in both paraffined and non-paraffined sectors penetrated in fairly pronounced streaks maximally to a depth of 35 mm. from the tangential sur-

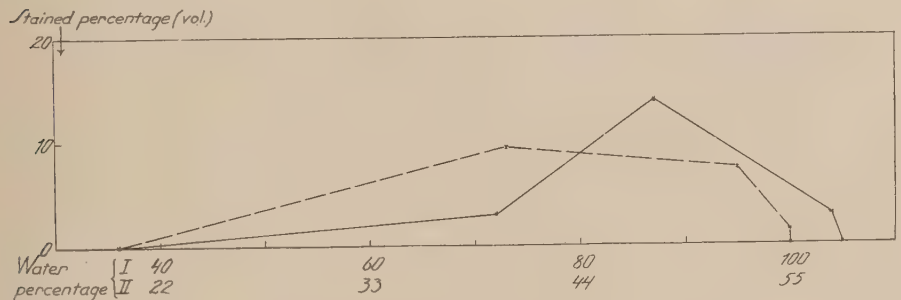


Fig. 80. Blueing by *Trichosporium tingens* in broad-ringed pine with secondarily free water. Paraffined (——) and non-paraffined (sectors).

Blånad av *Trichosporum tingens* i frodvuxen tall med sekundärt fritt vatten. Paraffinerade (——) och ej paraffinerade (- - - -) sektorer.

face. The streaks were restricted to the central portions of the sectors and were very narrow, making the percentage of blueing very small, not more than 14 %. The fungus behaved in approximately the same manner in paraffined and non-paraffined sectors (fig. 80). At about 60 % degree of saturation (110 % I) it developed very feebly. The rapidity of growth was augmented with diminished water content of the sapwood, for the optimum appeard to lie at about 48 % degree of saturation (87 % water content I). The lower limit for development was above 36 % water content (I).

Ceratostomella cœrulea caused extremely faint, hardly noticeable blueing. The optimal water content for the growth was in paraffined sectors about 46 % degree of saturation (83 % water content I); in the non-paraffined sectors there was, on the other hand, a wider optimal zone of growth, such as is the case in freshly felled timber. At 24 %

water content (I) (13 % degree of saturation) the conidia had certainly germinated on the tangential surface and formed a colony of hyphæ 20 × 10 mm., but the hyphæ nevertheless had only been able to penetrate into the outermost ring without, however, causing any discoloration.

Discula pinicola and *Leptographium Lundbergii* caused pronounced blueing. The colouring produced by the latter was, however, as a rule not so pronouncedly black-green as in corresponding tests with freshly felled timber. The course of the growth-curves above 55 % degree of saturation (100 % I) could only be determined for *Discula pinicola* (fig. 81). At 63 % degree of saturation (115 % I) the rate of blueing

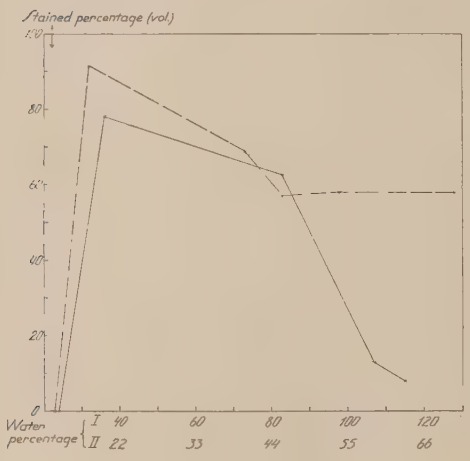


Fig. 81. Blueing by *Discula pinicola* v. *mammosa* in broad-ringed pine with secondarily free water. Paraffined (—·—) and non-paraffined sectors.

Blånad av *Discula pinicola* v. *mammosa* i frodvuxen tall med sekundärt fritt vatten. Paraffinerade (——) och ej paraffinerade (- - -) sektorer.

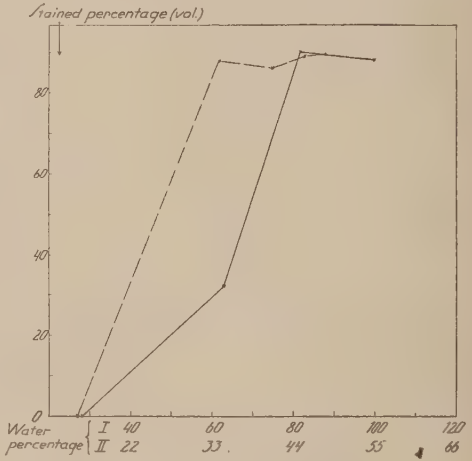


Fig. 82. Blueing of *Leptographium Lundbergii* in broad-ringed pine with secondarily free water. Paraffined (——) and non-paraffined (- - -) sectors.

Blånad av *Leptographium Lundbergii* i frodvuxen tall med sekundärt fritt vatten. Paraffinerade (——) och ej paraffinerade (- - -) sektorer.

in paraffined sectors was very slow; it rose rapidly at about 55 % degree of saturation (100 % I) and reached its optimum between 45 and 20 % degree of saturation (80 and 35 % I). From about 35 % water content (I) (20 % II) the curve dropped almost perpendicularly. In non-paraffined sectors the percentage of blueing was already high at 70 % degree of saturation (178 % I); it rose, however, with a lower water content, and reached its maximum between 40 and 18 % degree of saturation (73 % and 32 % I).

Leptographium Lundbergii (fig. 82) showed optimal growth at 55—35 % degree of saturation (100—60 % I). How the curves behave at a higher water content, has not been investigated. The lower limit for growth

Table 8. **Blueing of spruce (broad-ringed) with different water contents. The tree was felled on the 3rd April, 1924. The sectors were air-dried during the summer, after which they were immersed in water. The tests were commenced on the 13th December, 1924. Test-period 30 days. Normal room temperature.**

Blånad å gran (frodvuxen) med olika vattenhalt. Träden avverkades den 3:e april 1924. Sektorerna lufttorkades under sommaren, varefter de förvarades nedsänkta i vatten. Försöken började den 13 december 1924. Försökstid 30 dagar. Rumstemperatur.

Fungus Svamp	No.	Paraffined sectors Sektorerna paraffinerade					Non-paraffined sectors Sektorerna ej paraffinerade				
		Water content Vattenhalt			Blueing Blånad		Water content Vattenhalt			Blueing Blånad	
		I %	II %	of original water content % av den ursprungliga %[1]	in % of sector av sektorn %	colour färg	I %	II %	of original water content % av den ursprungliga %[1]	in % of sector av sektorn %	colour färg
Ceratostomella Piceæ	1	128	62	88	0	0	107	52	73	0	0
	2	82	40	56	0	0	93	45	64	0	0
	3	31	15	21	0	0	64	31	44	0	0
	4	27	13	18	0[1]	0	33	16	23	0	0
	5	25	12	17	0	0	28	14	19	0[1]	0
					0						
Endoconidiophora cærulescens	1	105	51	72	0	0	113	55	77	0	0
	2	79	38	54	0	0	76	37	52	0	0
	3	71	34	49	0	0	63	30	43	0	0
	4	69	33	47	0	0	55	27	38	0	0
	5	30	14	21	0	0	31	15	21	0	0
Hormonema dematioides.	1	125	60	86	31	X	122	59	84	33	X
	2	115	56	79	30	X	114	55	78	42	X
	3	91	44	62	34	X	86	42	59	40	X
	4	90	43	62	37	X	83	40	57	37	X
	5	46	22	32	47	X	27	13	18	0[2]	0
	6	28	14	19	0[2]	0	25	12	17	0[2]	0
Xylomyces I	1	118	57	81	36	X	115	56	79	40	X
	2	87	42	60	38	X	114	55	78	36	X
	3	84	40	58	46	X	79	38	54	42	X
	4	83	40	57	37	X	44	21	30	32	X
	5	55	27	38	43	X	28	14	19	0[2]	0
	6	28	14	19	0[2]	0	25	12	17	0[2]	0
	7	26	13	18	0[2]	0	—	—	—	—	—

[1] Despite the low water content graphia had developed fairly abundantly on the tangential surface of the sector. With a higher water content plenty of graphia were developed.

[2] Colonies of the inoculated fungus had developed on the tangential surface, although the hyphæ had not penetrated into the wood.

was slightly below 28 % water content (I) (15 % II). With the last-mentioned water content the conidia had germinated, but the hyphæ were unable to penetrate into the wood.

Test-Series 7. Spruce-wood (broad-ringed) with different water contents. The tree was felled on the 3rd April, 1926. The tests commenced on the 13th December, 1924, and went on for 30 days.

The timber came from the same tree as was used for test-series 1 and 2 (*a*).

The sectors were taken from the middle portion of the trunk, which measured 16 cm. in diameter and had 30 rings. Thickness of sapwood 6 cm.; width of rings, 2,8 mm.

The water content (I) in sapwood of the freshly felled timber was 146 %, its water capacity 206 %.

The air-dried sectors were treated as in the preceding test-series.

The species used were: *Ceratostomella Piceæ*, *Xylomyces* I, *Hormonema dematioides*, *Endoconidiophora cœrulescens*.

Ceratostomella Piceæ and *Endoconidiophora cœrulescens* had in no instance caused blueing (Table 8). They had to a water content (I) of about 30 % developed a more or less abundant mycelium, the former also had numerous graphia upon the surface, but inside the wood hyphae could be observed only in the outermost ring of the sapwood. These were colourless and had not caused any discoloration whatsoever. *Hormonema dematioides* and *Xylomyces* I, on the other hand, had caused considerable blueing although the colour was not particularly strong. The curves for the rapidity of blueing took approximately the same course for both species, no matter whether the sectors were paraffined or not (Table 8). It could not be determined at which upper water content blueing ceased; but the growth of the fungi commenced with a water content above 55—60 % degree of saturation (115—125 % I), and extended to about 22 % degree of saturation (45 % I). At 25 % water content I (12 % II) small colonies developed around the conidia or inoculation mycelia, but the hyphæ had penetrated only into the first ring without, however, causing any discoloration.

5. Discussion of the results.

The investigations elucidated that the fungi behave very differently in wood with primarily free water than in wood with secondarily free water. In conjunction with the practical experiments mentioned below concerning the effect of different forms of storage upon the development of blueing in round-timber the blueing capacity of the fungi in wood

of the first-mentioned type is here of major interest. Tests with wood of the latter type are, however, important from another practical point of view. They illustrate, for example, the conditions in sawn, air-dried timber that is later exposed to moisture.

Of wood with primarily free water, both pine and spruce have been investigated.

In the winter-felled pine-timber the rapidity of growth of the fungi and intensity of blueing were, on the whole, not the same in paraffined and non-paraffined sectors. In test-series 3 with a natural water content [70 % degree of saturation (145 %) I] all the species investigated, viz. *Ceratostomella cœrulea*, *Discula pinicola*, *Trichosporium tingens* and *Leptographium Lundbergii*, had an extremely low rate of blueing in the paraffined sectors. After three weeks the hyphæ from the tangential surface had penetrated at the most 2 mm., and caused only a very faint, scarcely noticeable discoloration. The condition was, in the main, the same when the water content in the sapwood was increased by 10 %. In the non-paraffined sectors in the same tests with natural water content only *Discula pinicola* and *Trichosporium tingens* had been greatly retarded or prevented from penetrating into the wood, while *Ceratostomella cœrulea* and *Leptographium Lundbergii* had caused blueing of respectively 13 % and 25 % of the sectors. Of the two latter species, only *C. cœrulea* was investigated as to its relation to a higher water content than the natural one, viz. 83 % II (171 % I), at which the hyphæ had been able to penetrate only 1 mm. from the surface, causing a very faint discoloration.

The reduction of the natural water content by 10 % had been sufficient in the non-paraffined sectors for the fungi to reach their optimal development (*Trichosporium tingens* and *Leptographium Lundbergii*), whereas in paraffined sectors this was reached first with a reduction of 60—80 %. In the former case the fungi showed a broad optimal zone extending from about 61—67 % degree of saturation (126—137 % I) to about 20 % degree of saturation (40 % I). In the latter, on the other hand, the strictly limited optimum for the separate species was somewhat different, viz. at about 17—30 % degree of saturation (about 34—62 % I).

The lower limit for the growth lies at the same water content in paraffined and non-paraffined sectors. In the pine-tests referred to the lower limit of development lay for:

Ceratostomella cœrulea just below 27 % water content (I),
Discula pinicola, *Trichosporium tingens*, *Leptographium Lundbergii* } just above 28 % water content (I).

Of the species investigated in test-series 4, *Hormonema dematioides*, *Hormodendrum cladosporioides* and *Alternaria humicola* gave growth-curves (fig. 75—77) of approximately the same appearance as the aforesaid species, even when the upper limit was at a somewhat higher water content in the former than in the latter. *Hormodendrum* and *Alternaria* showed in paraffined sectors a comparatively slight growth at 78 % degree of saturation (155 % I), while *Hormonema* at the same water content had developed fairly well. The growth improved in all cases successively with a diminished water content to about 35 % water content I (16 % II). In the non-paraffined sectors the optimal zone was already reached at about 70 % degree of saturation (155 % I).

Ceratostomella Pini represents a type deviating from the others that have been investigated, inasmuch as both in paraffined and non-paraffined sectors the growth-curves already reached their maximal height at 73—77 % degree of saturation (163—171 % I).

The cause of the different development of most of the fungi in paraffined and non-paraffined sectors was perhaps primarily because the air circulation was of a different degree of intensity. The blueing fungi are, as especially MÜNCH (l. c.) has pointed out, and as we proved with respect to the species isolated by us, strictly aerobic organisms. In winter-felled timber with natural water content the oxygen content had in most cases obviously been too small in the outer portions of the sapwood for the fungi to be able to thrive. If therefore oxygen in the course of the tests was prevented from penetrating from the incision surfaces (tests with paraffined sectors) the fungi — exceptions are *Ceratostomella Pini* and *Hormonema dematioides* — were able to penetrate only into the outermost rings in three weeks. If the sectors were not paraffined, on the other hand, such a large quantity of oxygen diffused in that the majority of the species were able to reach a fairly strong development. In the latter case *Ceratostomella Pini* and *Hormonema dematioides* developed best, already reaching their optimal rate of growth at a loss of water of 2—3 %. The blueing caused by *Ceratostomella cœrulea* and *Leptographium* with a natural water content was most intense close to the incision surfaces, where the air circulation and resultant supply of oxygen was obviously greatest. For *Discula pinicola* and *Trichosporium tingens* the supply of oxygen in the sapwood with a natural water content was too little for the fungi to thrive.

In the partially dried sectors the most favourable oxygen content for the fungi was obtained at a loss of water of 60—80 %, if the sectors were paraffined. An exception was *Ceratostomella Pini.* On the other hand, the most favourable oxygen content occured with a loss of water of about 10 %, when the sectors were paraffined, except *C. Pini* and *Hormonema dematioides.* A further increase in the supply of oxygen under continued drying in the latter case did not cause improved growth, but the curves ran horizontally until, through lack of water, they dropped rapidly.

From the tests it must be concluded that not all the species have the same need of oxygen. To those most in need of oxygen belong *Discula pinicola* and *Trichosporium tingens.* Somewhat less exacting are *Ceratostomella cœrulea*, *Leptographium*, *Hormodendrum cladosporioides* and *Alternaria humicola;* and least exacting *Hormonema dematioides* and *Ceratostomella Pini.* The last-mentioned species in paraffined sectors already reached its optimal development at a loss of water of 7 % (73 % degree of saturation), while *Hormonema* with the same water content caused blueing which was 40 % of the maximal.

It has been pointed out in the preceding that the maximal percentage of blueing as a rule was not equally as great in paraffined as in non-paraffined sectors (cf. fig. 70—73, 76—77). This dissimilarity appears to us explicable, because in the former case the optimal need of oxygen was never reached. Because of an insufficient supply of oxygen most of the fungi in paraffined sectors never reached perfectly optimal development. *Ceratostomella Pini* and *Hormonema dematioides* formed an exception here, too (fig. 74, 75). This feature is most striking in the first-mentioned species, which from 73 % degree of saturation (163 % I) to 18 % degree of saturation (39 % I) had developed equally well in paraffined and in non-paraffined sectors. Obviously, this condition was due to a lesser need of oxygen on the part of the species referred to.

The spruce-wood used for the investigations was not equally favourable for the fungi in different tests. Both in *a* and in *b* of test-series 2 *Endoconidiophora cœrulescens* developed very rapidly and caused intense blueing, while the same species in test-series 5 grew much more slowly and produced less pronounced blueing. The reason of this difference should probably be looked for in the wood itself, the wood in the first instance being broader-ringed than in the latter. Besides, there may nevertheless exist certain chemical differences, which will be touched upon later. Quite a number of blueing fungi behave extremely erratically towards spruce-wood. In some cases they may develop well; in other in-

stances, on the other hand, feebly, without any appreciable differences existing as regards the density of the rings in the wood (see below).

The most complete culture-tests on spruce with different water content were made upon timber which was obviously less favourable to the fungi (test-series 5). They can therefore not be generalised on, but hold good only for the type of timber less favourable to the fungi. The spruce-tree felled for the tests referred to had an abnormally low water content in the sapwood, viz. 47 % degree of saturation (85 % I). Despite this low water content, *Endoconidiophora cœrulescens, Hormonema dematioides* and *Xylomyces* I did not penetrate into the freshly felled timber. The optimal zone was situated at about the same water content in paraffined and non-paraffined sectors, viz. for *Endoconidiophora* between 41 and 42 % degree of saturation (74—57 % I); for *Hormonema* and *Xylomyces* I between about 46 and 28 % degree of saturation (about 85—50 % I). The lower limit for the blueing capacity was situated for the former species at about 40 % water content I; for *Hormonema* and *Xylomyces* I at about 30%.

In spruce-wood more favourable to the fungi, tests were made only with *Endoconidiophora cœrulescens*. The sectors were not paraffined. With a natural water content this developed very well, and had after 30 days penetrated 35 mm. At 6% loss of water the growth-curve reached its maximal position, which was maintained until beyond 40 % (I), after which it dropped rapidly. The lower limit was just above 34 % water content (I). The curve for *Endoconidiophora* coincided closely in its course with the growth-curve for the majority of species tested in pine.

It is of a certain interest to compare the behaviour of the fungi in wood that is favourable and unfavourable to them. Besides the difference in the rapidity of growth and intensity of blueing with optimal water content, we found considerable difference with respect to the upper and lower limits. This held especially good with respect to the upper limit. The upper limit in wood favourable to the fungi was situated at a considerably higher water content than in less suitable wood. Besides *Endoconidiophora*, direct comparisons can be drawn with respect to *Hormonema*, whose upper limit of growth in the pinetest (Test-Series 4) was above 76 % degree of saturation; in the spruce-test (Test-Series 5), on the other hand, below 49% degree of saturation; in both instances in non-paraffined sectors[1]. There is thus reason

[1] In this connection it may be stated that in the spruce-tests mentioned in Test-Series 7 (broad-ringed wood with secondarily free water) the upper limit for the growth of *Hormonema* and *Xylomyces* I was higher than 60 % degree of saturation (125 % I), thus higher than in the said tests with close-ringed spruce.

to assume that the need of oxygen of the fungi increases when the conditions otherwise are unfavourable in some way or other.

The tests carried out tend to prove the result arrived at by MÜNCH (1908, 1909) with regard to *Ceratostomella Pini* and *C. cærulea*, viz. that the supply of oxygen is a decisive factor for the growth of the fungi at a high water content in the timber. The wood must hold a definite quantity of oxygen to enable fungi to thrive and cause blueing. The oxygen cannot be conveyed through the mycelium from without, but must be present in the wood where it is to be consumed. As mentioned, it is nevertheless seen from the tests that not all the blueing fungi have the same need of oxygen. To the least exacting in this respect belong *Ceratostomella Pini*, *Endoconidiophora cærulescens* and *Hormonema dematioides*. Besides this, it seems to be quite apparent that the need of oxygen increases in the same degree as the conditions are otherwise unfavourable to the fungi.

In normal living trees the outer sapwood seems to contain too little oxygen for the majority of the blueing fungi. This is at least the case during the winter, when the water content of the sapwood is greater than during the summer (cf. below). On the other hand, there exists in the inner sapwood, where the water content is lower, sufficient oxygen for enabling at least some species to develop. *Endoconidiophora cærulescens* and *Discula pinicola* had, as mentioned above (cf. p. 196 and 211), penetrated from incisions produced by blazed growing spruce, and had caused pronounced blueing in the inner sapwood.

In our tests with winter-felled spruce and pine with natural water content it frequently happened that the fungi from the incision surfaces penetrated into the inner sapwood, which was intensely coloured, while the outer sapwood remained intact. This was particularly the case with *Ceratostomella cærulea*, *Trichosporium tingens* and *Leptographium Lundbergii*. Similar observations were made by MÜNCH (1908, 1909) in his tests. This phenomenon can only be due to the oxygen content being greater in the outer than in the inner portions of the sapwood[1].

It is therefore probable that the outer sapwood in living trees forms a protective barrier against the penetration of blueing fungi. If, on the other hand, after felling the water disap-

[1] This oxygen might partly be derived from atmospheric air, which on account of negative pressure in the living tree had diffused in after felling.

pears, air penetrates into the cells and conditions become thus more favourable for the fungi. Up to a certain limit, the greater the loss of water, the better they thrive. In timber from broad-ringed, winter-felled pine they reach their optimal development — as in the paraffined sectors — first with a loss of the natural water content of about 60—80 % in the sapwood, unless cracks occur which facilitate air circulation. On the other hand, an optimum occurs already with a fairly slight loss of water in sawn timber, for example where, similarly to the conditions in non-paraffined sectors, oxygen can diffuse in with greater ease.

In MÜNCH's aforesaid tests with *Ceratostomella cærulea* in winter-felled pine the curve for the rapidity of blueing reached its maximum at about 35 % loss of water, after which it appeard to take an approximately horizontal course to about 70 % loss of water[1]. MÜNCH's curve rose thus much more slowly than the curves for our non-paraffined pine-sectors, but on the other hand much more rapidly than the curves for the paraffined ones. The reason of these different results might have to be looked for in the different arrangements used for the tests. MÜNCH, as has been mentioned, made use of 10—12 cm. high, non-paraffined cross-sections of trunk. Obviously the circulation of air in these was greater than in our paraffined sectors, but, on the other hand, less than in our non-paraffined ones. It is possible that the blueing optimum in felled, broad-ringed timber may be already reached with a loss of water of 35 % in concurrence with MÜNCH, viz. if it concerns small dimensions. Our practical tests mentioned below confirm, however, that the results in respect of the paraffined sectors on the whole coincide with the conditions in stored round-timber.

After the blueing-maximum has been reached, it is the quantity of water available for the hyphæ which is decisive for their growth. One may say that the capacity of blueing practically ceases when there is no more free water in the cells, i. e. at the so called fibre-saturation point. Different species behave, however, somewhat differently with respect to the lower limit. Thus, for example, the limit for the development of *Endoconidiophora cærulescens* lies slightly higher than that for other species investigated.

MÜNCH is of opinion that *Ceratostomella cærulea* still develops in timber and causes blueing when all free water has disappeared from the cells. The water imbibed in the cell-walls would thus be sufficient for

[1] The figures which have been calculated from the values supplied by MÜNCH relate to entire cross-sections.

the growth. The estimates of the quantity of free water in the cells drawn up by MÜNCH appear, however, not to be sufficiently safe for such a conclusion. For, as has been mentioned, the water content has been calculated for the entire cross-section, without taking account of the original difference in this respect between the outer and inner rings. In those cases where the hyphæ according to MÜNCH's calculations only received imbibition water[1], free water may thus in reality still have been present at least in the outer sapwood.

According to HARTIG (1882) the fibre-saturation point for sapwood of *Pinus silvestris* lies at a water content of 32—36 % (I), and for sapwood of *Picea excelsa* at 39—41 %. If we assume that these figures are correct, *Ceratostomella cœrulea*, *Discula pinicola* and *Trichosporium tingens* should develop well even at the fibre-saturation point. HARTIG's determination of the imbibed water in timber call, however, for renewed tests with improved methods. It may be mentioned in this connection that ZELLER (1920) discovered the fibre-saturation point in *Pinus echinata* and *P. palustris* to lie at respectively 24,25 and 23,75 % water content (1). These values coincide well with those obtained previously by TIEMANN (1907).

It seems probable that the blueing fungi demand free water in the parenchyma cells of the wood in order to be able to reach a development strong enough for the timber to be discoloured. Even if a feeble growth should exist at, and immediately below, this limit, it is nevertheless without practical significance. It is probable that the need of free water on the part of the blueing fungi is one of the reasons why they are on the whole not able to penetrate into the heart.

If we then examine into the conditions present in air-dried wood we shall find that the majority of fungi thrive more poorly here than in timber with primarily free water. There was nevertheless a palpable difference between on the one hand the *Pyrenomycetes* and the *Sphæropsidaceæ* and *Hyphomycetes* on the other hand. The former did not as a matter of fact cause any blueing (*Endoconidiophora cœrulescens*, *Ceratostomella Piceæ*), or an extremely feeble one (*Ceratostomella cœrulea*). The blueing caused by the *Hyphomycetes* was in most cases (*Hormonema*, *Trichosporium*, *Leptographium*, *Xylomyces* I) fainter than in timber with primarily free water. *Discula pinicola*, on the other hand, had in both cases caused blueing of approximately the same intensity of colouring.

It is evident that the wood through drying and subsequent immersion

[1] At 29—33 % water content I, calculated for the entire cross-section.

passed through certain changes unfavourable for the majority of the species. When newly felled, the same timber was tested as to its relation to *Ceratostomella cærulea*, *Endoconidiophora cærulescens* and *Trichosporium tingens*, all of which developed more or less strongly. It is probable that the other species would have behaved in the same manner.

What these changes are, cannot be said at present. It is highly probable that it is a question of removal of water soluble substances due to the immersion of the sectors, combined with fermentation processes caused by bacteria, by which means the original content of assimilatives has been decimated.

It has been possible to prove that some organic compounds have disappeared or been changed. Thus, by way of example, the pith-rays in the spruce sectors from the beginning contained an abundance of starch which could not be proved to be present after immersion. But, on the other hand, there was present both in the pine and spruce sectors an abundance of fats which had not been appreciably decimated by immersion.

Probably other causes, too, have contributed towards the feebler development of the fungi. Certain substances detrimental to the blueing fungi have possibly developed through the agency of micro-organisms.

It is nevertheless practically important to prove that even air-dried timber after renewed absorbtion of water is subject to blueing, even ift he attacking species are fewer in number, and the blueing frequently less pronounced than in fresh timber. This question is particularly important as far as sawn timber is concerned. Even after this has been completely air-dried, it must be protected from water. Change of storage or loading in rainy weather may thus entail very detrimental results, all the more so as the blueing limit is situated at such a low water content as approximately 30 % (I).

B. Influence of temperature upon the development of blueing fungi.

The growth of blueing fungi at different temperatures has previously been investigated chiefly by MÜNCH (1908) and FALCK (1916). MÜNCH did not produce any complete culture-series through lack of thermostats. He states, however, that *Endoconidiophora cærulescens* germinates and grows at a lower temperature than other species: at 7° C a slow growth could be observed on gelatine. Although the optimal temperature has not been empirically determined, MÜNCH considers it to lie above 20—25° C for all species. Those blueing fungi with which MÜNCH worked were, as stated, *Endoconidiophora cærulescens* and species of *Ceratostomella*.

According to FALCK the optimal temperature lies at 25° C in cultures upon wort-agar; at 10° C the rate of growth is only $^1/_5$ of the optimal; and below 5° C growth ceases entirely.

The growth during two days was (l. c. p. 144):

at	10°	14°	18°	22°	25°	27°	34° C.
about	7	14	22	30	35	30	0 mm.

Unfortunately it is not apparent on which species the temperature-values are based. The great rapidity of growth upon wort-agar argues against it being a species of *Ceratostomella*. *C. Piceæ*, to which FALCK refers, grows as a matter of fact also relatively slowly upon malt-agar. This is the case also with other species of *Ceratostomella* (*C. cærulea*, *C. pluriannulata* and *C. Pini*) investigated by us. Of our species, *Endoconidiophora cærulescens* and *Leptographium Lundbergii* develop most rapidly on malt-agar. As the temperature-curve obtained by us for the latter species agrees very well with the values given by FALCK, our conception that FALCK used this species in his culture-tests, advanced in the preceding (p. 253), is still further confirmed by this.

More recently HOWARD (1922, p. 16) states that the optimal temperature as a rule presumably lies at 80° to 85° F (i. e. 27°—29° C). He points out, however, as a probability that every species has its characteristic temperature-curve.

With regard to the temperature-demands the following species were investigated:

Ceratostomella cærulea, *C. Piceæ*, *Endoconidiophora cærulescens*, *Trichosporium tingens*, *Leptographium Lundbergii* and *Xylomyces* I.

The cultures were grown in petri-dishes upon malt-agar[1]. After normal colonies had developed the growth was measured along four radii according to FALCK's method (FALCK 1907, MELIN 1925).

Through preliminary tests it was found that the radial growth of the colonies is not quite uniform, such as is the case in, for example, *Phycomycetes* and wood-destroying *Hymenomycetes*. As is well-known, FALCK (l. c.) has proved in regard to these that the growth of the hyphæ in the cultures soon assumes a definite value which subsequently remains constant, no matter how long the observations are continued. In the species investigated by us, contrary to the said fungi, there exists a certain periodicity with respect to rapidity of growth. This becomes most clearly apparent in *Endoconidiophora* and the *Hyphomycetes*. In these the growth is greatly increased during the first period, at 13,5° C. e. g. during the first 7—9 days, after which it again diminishes. This condition

[1] 5 % malt-extract (LIEBIG); 1,5 % agar-agar.

is illustrated by Table 9, where the growth at 13,5° C during succeeding two-day periods has been summarised.

In order to obtain values fully comparable with each other it was necessary on account of the aforesaid periodicity, to carry out a whole series of growth-measurements in every separate case. These were made every other day, reckoned from the third or fourth day from commencement of test. For each temperature-value two cultures of the same species of fungus were used.

The results are given in fig. 83 and 84. It will be seen that *Endoconidiophora cœrulescens* and *Leptographium Lundbergii* have a fairly restricted optimum on malt-agar; the former at 22,5° C; the latter at 25° C. The other species investigated, however, have a wide optimal zone which gene-

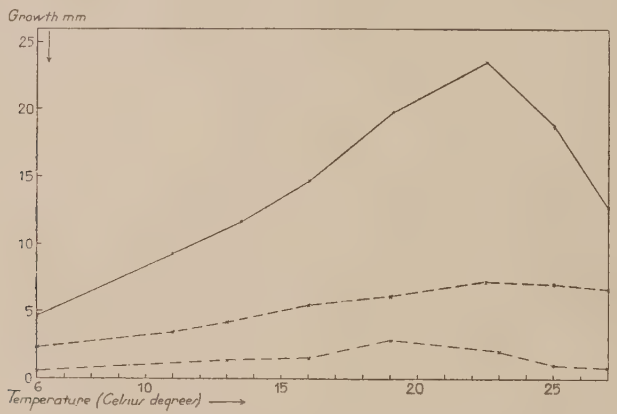


Fig. 83. Temperature-curves for *Endoconiphora cœrulescens* (——), *Ceratostomella cœrulea* (— — —), and *Xylomyces* I (— · — · —).

Temperaturkurvor för *Endoconidiophora cœrulescens* (——), *Ceratostomella cœrulea* (— — —) och *Xylomyces* I (— · — · —).

ally culminates at about 22,5° C, with the exception of *Xylomyces* I which upon malt-agar has its optimum at about 19° C. The minimum temperature has not been determined, but probably lies just above zero. As a matter of fact at 3—4° C growth could still be shown upon malt-agar. The maximal temperature lies above 27° C.

WOLPERT (1924) recently found with respect to wood-destroying fungi that the optimal temperature to a certain extent varies with the substratum. In spite of these variations he was nevertheless able to divide the species investigated into three groups which have their optimal zones at high (about 35° C), medium (about 25° C), and low (about 15° C) temperature respectively. Even if thus it is impossible to draw any cert-

ain or safe conclusions regarding the temperature needs of the fungi in wood from the tests carried out upon malt-agar we may yet be able to say that the species studied on the whole reach their optimal development at medium temperatures (22—25° C). They grow nevertheless fairly well at about 15° C, and still develop at very low temperatures.

If external conditions are in other respects unfavourable the upper and lower limits will, however, certainly move in the direction towards optimum. Thus, for example, at an unfavourable water content in the

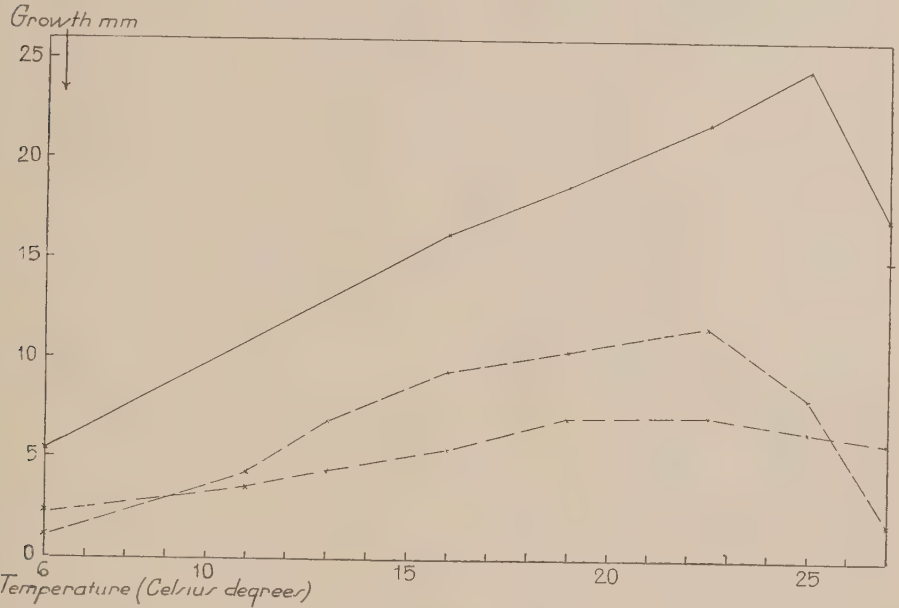


Fig. 84. Temperature-curves for *Leptographium Lundbergii* (——), *Trichosporium tingens* (— — —). and *Ceratostomella Piceæ* (— · — · —).
Temperaturkurvor för *Leptographium Lundbergii* (——) *Trichosporium tingens* (— — —) och *Ceratostomella Piceæ* (— · — · —).

timber the maximum for the growth may possibly lie considerably lower than in the tests upon malt-agar. No tests for confirming this theory have, however, been carried out.

C. The influence of the timber itself upon the development of the blueing fungi.

1. Do blueing fungi develop more easily in pine than in spruce-wood?

It is a generally accepted theory that spruce (*Picea excelsa)* is less subject to blueing than pine *(Pinus silvestris).* Owing to this, at many

Table 9. Growht of *Ceratostomella cœrulea*, *C. Piceæ*, *Endoconidiophora cœrulescens*, *Trichosporium tingens* and *Leptographium Lundbergii* upon malt-agar at 13,5° C.

Tillväxt av *Ceratostomella cœrulea*, *C. Piceæ*, *Endoconidiophora cœrulescens*, *Trichosporium tingens* och *Leptographium Lundbergii* på maltagar vid 13,5° C.

Species / Art	Days from commencement of test / Dagar från försökets början	Test I Försök I — Radius Radie I mm	II mm	III mm	IV mm	Average Medeltal mm	Test II Försök II — Radius Radie I mm	II mm	III mm	IV mm	Average Medeltal mm
Ceratostomella cœrulea	4—5	4	4	4	4	4 ± 0,0	4	4	4	4,5	4,1 ± 0,2
	6—7	4	4	5	4	4,3 ± 0,4	4	4	4	4,5	4,1 ± 0,2
	8—9	5	5	4	5	4,8 ± 0,4	5	5	5	4	4,8 ± 0,4
	10—11	5	5	6	5	5,3 ± 0,4	5	5	5	5	5 ± 0,0
	12—13	5	5	5	5	5 ± 0,0	5	5	5	5	5 ± 0,0
Ceratostomella Piceæ	4—5	4	4	4	4	4 ± 0,0	4,5	4	4	4,5	4,3 ± 0,3
	6—7	4,5	4,5	5	5	4,8 ± 0,3	4,5	4,5	4,5	4,5	4,5 ± 0,0
	8—9	5,5	5,5	5	5	5,3 ± 0,3	5	—	4,5	5	4,8 ± 0,2
	10—11	5	5	4	5	4,8 ± 0,4	6	—	6	5	5,7 ± 0,4
Endoconidiophora cœrulescens	4—5	10,5	10	10	9	9,9 ± 0,4	10	10,5	10,5	10	10,3 ± 0,3
	6—7	12,5	13	13	13	12,9 ± 0,2	13	13,5	13,5	13	13,3 ± 0,3
	8—9	16	16	16	16	16 ± 0,0	15	14	14	14	14,3 ± 0,4
	10—11	14	14	14	14	14 ± 0,0	14	14	14	14	14 ± 0,0
Trichosporium tingens	4—5	5	5	5	6	5,3 ± 0,4	4	6	8	3	5,3 ± 1,8
	6—7	9	8	10	8	8,8 ± 0,8	8	10	5	9	8 ± 1,5
	8—9	8	9	8	9	8,5 ± 0,5	9	8	9	9	8,8 ± 0,4
	10—11	8	9	6	8	7,8 ± 1,0	6	7	7	6	6,5 ± 0,5
	12—13	—	—	—	—	—	8	8	8	8	8 ± 0,0
Leptographium Lundbergii	4—5	6	6	5	6	5,8 ± 0,4	7	6	7	6	6,5 ± 0,5
	6—7	12	11	10	10	10,8 ± 0,8	8	9	8	9	8,5 ± 0,5
	8—9	14	16	17	16	15,8 ± 0,9	13	13	15	12	13,3 ± 0,9

Swedish saw-mills only spruce is sawn during the height of summer. In many instances, however, experience shows that also the spruce is attacked by blueing-fungi. These contradictory experiences seem to speak in favour of the assumption that the fungi do not always react in the same manner on the spruce.

In order to investigate how different species react on pine and spruce, two series of experiments with 10 species of isolated fungi were started. Both winter-felled and spring-felled pine *(Pinus silvestris)* and spruce *(Picea excelsa)* were used. In all the cases the wood was broad-ringed. Heartwood was practically lacking.

Test-Series 8. Winter-felled pine and spruce.

Test-Series 9. Spring-felled pine and spruce.

The nature of the timber in the two test-series will be seen in Table 10.

Table 10. **Timber used in Test-Series 8 and 9.**
Det i försöksserierna 8 och 9 använda virket.

Tree felled Trädet avverkat	Sections used De använda sektionernas				
	Diameter	Age years Ålder år	Width of annual ring in sapwood mm. Årsringsbredd i splinten mm	Water content in sapwood Vattenhalt i splinten	
				I %	II %
Pine *a* Jan., 1925	16	40	2	125	80
Tall » *b* 23rd April, 1925	16	38	2,1	120	64
Spruce *a* Jan., 1925	16	28	2,7	196	91
Gran » *b* 23rd April, 1925	17	38	2,2	118	69

The sectors were dried to a water content (40—60 % II) optimal for the blueing fungi, after which they were partially sterilised in the previously mentioned manner.

Unfortunately a large amount of water was lost in the sterilisation of the sectors from the spring-felled timber (Table 12), because the glass-jars used did not close tight. For this reason the water content in these sectors fell below that originally intended. In four experiments with pine *(Discula, Hormonema, Hormodendrum, Leptographium)* and in one with spruce *(Leptographium)* the water content fell below 40% (1)[1].

[1] The growth of the fungi in the last-mentioned sectors can probably not be compared directly with that in the corresponding sectors from winter-felled timber, if we except *Hormonema*, which, in spite of the low water content (32 % I), had penetrated to the sapwood limit.

Table II. **Rapidity of development of various blueing fungi in winter-felled, broad-ringed pine and spruce-wood.**
Test-period three weeks. Normal room temperature.
Olika blåytesvampars utvecklingshastighet i vinteravverkat, frodvuxet tall- och granvirke. Försökstid tre veckor. Rumstemperatur.

Fungus Svamp	Number of months in pure culture Ympstammens antal månader i kultur	Pine Tall: Water content Vattenhalt I %	Pine Tall: Water content Vattenhalt II %	Pine Tall: Blueing Blånad % of sector % av sektorn	Pine Tall: Blueing Blånad Colour Färg	Spruce Gran: Water content Vattenhalt I %	Spruce Gran: Water content Vattenhalt II %	Spruce Gran: Blueing Blånad % of sector % av sektorn	Spruce Gran: Blueing Blånad Colour Färg
Ceratostomella cærulea	15½	71	46	*10*	XXX	114	53	*9*	o—X
Endoconidiophora cærulescens	13	84	54	*89*	XXX	119	55	*75*	XX
Discula pinicola v. *mammosa a*	15½	76	49	*79*	XXX	117	54	*44*	XX
» » » » *b*	7½	75	48	*82*	XXX	103	48	*47*	XX
Hormonema dematioides	19½	91	58	*86*	XXX	129	60	*26*	XX
Trichosporium tingens	15½	78	50	*86*	XXX	118	55	*64*	XX
Hormodendrum cladosporioides	7½	72	46	*51*	XXX	89	41	*14*	o—X
Leptographium Lundbergii	7	67	43	*78*	XXX	110	51	*58*	XX
Cadophora fastigiata	7	95	61	*8*	XXX	135	63	*8*	XX
Xylomyces I	15½	74	47	*81*	XX	118	55	*49*	X

The experiments were commenced immediately after the felling of the trees and continued for three weeks. The results are summarised in Tables 11 and 12. The size of the sectors being practically the same in the four tests, the figures for the percentages of blueing may be directly compared with each other.

As far as the winter-felled pine is concerned the majority of species, viz. *Endoconidiophora cœrulescens*, *Discula pinicola*, *Hormonema dematioides*, *Trichosporium tingens*, *Hormodendrum cladosporioides*, *Leptographium Lundbergii* and *Xylomyces* I, developed very rapidly. After three weeks these caused intense blueing of the whole, or the greater part, of the sapwood. The slowest growing species were *Cadophora* and *Ceratostomella cœrulea*.

With regard to the latter it should, however, be pointed out that the slight rate of growth in the said tests is abnormally low in comparison with a number of earlier and later tests made with the same species (Tables 3 and 13). In the tests recorded in Table 13 the percentage of blueing by *C. cœrulea* in pine was 70 %. These dissimilarities were probably largely due to the different ages of the inoculation strains used. In the experiment recorded in Table 11, where the growth was feeble, an inoculation-strain was used which had been kept in pure culture for

Table 12. **Rapidity of development of various blueing fungi in spring-felled, broad-ringed pine and spruce.**
Test-period three weeks. Normal room temperature.
Olika blåytesvampars utvecklingshastighet i våravverkad, frodvuxen tall och gran. Försöks-tid tre veckor. Rumstemperatur.

Fungus Svamp	Number of months in pure culture Ympstam-mens antal månader i kultur	Pine Tall: Water content Vattenhalt I %	Pine Tall: Water content Vattenhalt II %	Pine Tall: Blueing Blånad % of sector % av sektorn	Pine Tall: Blueing Blånad Colour Färg	Spruce Gran: Water content Vattenhalt I %	Spruce Gran: Water content Vattenhalt II %	Spruce Gran: Blueing Blånad % of sector % av sektorn	Spruce Gran: Blueing Blånad Colour Färg
Ceratostomella cærulea	18½	60	33	*20*	XXX	71	42	*4*	o—X
Endoconidiophora cærulescens	16	56	30	*32*	XX	57	34	*0*	o
Discula pinicola v. *mammosa a*	18½	32	17	*62*	XXX	53	31	*0*	o
» » » » *b*	10½	62	34	*58*	XXX	74	44	*0*	o
Hormonema dematioides.....	22½	32	17	*91*	XXX	45	26	*0*	o
Trichosporium tingens	18½	47	25	*79*	XXX	64	38	*0*	o
Hormodendrum cladosporioides.....	10½	36	20	*35*	XXX	53	31	*0*	o
Leptographium Lundbergii..	10	30	16	*43*	X	31	18	*0*	o
Cadophora fastigiata.....	10	40	22	*25*	XXX	42	25	*2*	o—X
Xylomyces I	18½	70	38	*11*	XXX	81	48	*0*	O

15½ months, while in the last-mentioned test the inoculation strain was only 4½ months old. Like *Ceratostomella Piceæ*, *C. cærulea* seems to become debilitated through prolonged pure-culture upon an artificial substratum, something which also manifests itself, inter alia, in the perithecia-formation becoming more difficult upon malt-agar.

In winter-felled spruce-wood the fungi generally developed more slowly, and produced a less pronounced discoloration than in pine.

The most rapidly growing species were *Endoconidiophora cærulescens*, *Trichosporium tingens*, *Leptographium Lundbergii*, *Xylomyces I* and *Discula pinicola*. The rate of growth of these was 20—40 % less in spruce than in pine. Of other species, *Hormonema dematioides* and *Hormodendrum cladosporioides* developed very slowly in spruce as compared to pine. The rate of growth in spruce was namely only 30 % of that in pine. Besides, the blueing caused by the latter species was very feebly marked. *Ceratostomella cærulea* caused in spruce a scarcely noticeable discoloration which, however, had the same spread as in pine.

In the spring-felled timber we found a much greater difference with respect to the behaviour of the fungi in pine and spruce. In the spruce-tests only *Ceratostomella cærulea* and *Cadophora fastigiata* caused blueing which, however, was extremely faint. The other species did not

Table 13. **Rate of development of various blueing fungi in winter-felled, broad-ringed pine and spruce. Test-period 25 days. Normal room temperature.**

Olika blåytesvampars utvecklingshastighet i vinteravverket, frodvuxet tall- och granvirke. Försökstid 25 dagar. Rumstemperatur.

Fungus Svamp	Number of months in pure culture Antal månader i renkultur	Sector Sektor	Pine Tall Water content of sapwood Splintens vattenhalt I %	II %	% of sector % av sektorn	Average value Medelvärde	Blueing Blånad Colour Färg	Spruce Gran Water content of sapwood Splintens vattenhalt I %	II %	% of sector % av sektorn	Average value Medelvärde	Blueing Blånad Colour Färg
Ceratostomella cærulea	$4^1/_2$	I	109	49	*80*	**79 ± 1**	XXX	103	63	*15*	**13,5 ± 1,5**	XX
		II	116	52	*78*		XXX	119	73	*12*		XX
Ceratostomella Piceæ a	19	I	127	57	*0*	**0**	—	98	60	*0*	**0**	—
		II	108	48	*0*		—	93	57	*0*		—
» » *b*	$4^1/_2$	I	105	47	*38*	**32 ± 6**	X—XX	93	57	*0*	**0**	—
		II	78	35	*26*		X—XX	83	51	*0*		—
Ceratostomella pluriannulata	$3^1/_2$	I	77	35	*55*	**53 ± 2**	X—XX	86	52	*0*	**0**	—
		II	90	40	*51*		X—XX	90	55	*0*		—
Ceratostomella Pini a	$4^1/_2$	I	133	60	*89*	**86,5 ± 2,5**	XXX	105	64	*75*	**73,5 ± 1,5**	XX—XXX
		II	108	48	*84*		XXX	111	68	*72*		XX—XXX
» » *b*	$2^1/_2$	I	108	48	*89*	**88 ± 1**	XXX	118	72	*45*	**50 ± 5**	XX—XXX
		II	113	51	*87*		XXX	118	72	*55*		XX—XXX
Endoconidiophora cærulescens	$22^1/_2$	I	111	50	*89*	**90 ± 1**	XXX	112	68	*100*	**100 ± 0**	XXX
		II	110	49	*91*		XXX	111	68	*100*		XXX
Sclerophoma entoxylina a	$3^1/_2$	I	94	42	*89*	**88,5 ± 0,5**	XXX	115	70	*64*	**72 ± 8**	XXX
		II	90	40	*88*		XXX	96	59	*80*		XXX

Sclerophoma entoxylina b	1	I	128	58	*86*	**84,5 ± 1,5**	XXX	113	69	*74*	**70 ± 4**	XXX
		II	118	53	*83*		XXX	110	67	*66*		XXX
Discula pinicola	29	I	111	50	*89*	**88 ± 1**	XX	117	72	*9*	**11 ± 2**	X
		II	126	57	*87*		XX	116	71	*13*		X
» v. *mammosa a*	25	I	104	47	*93*	**92,5 ± 0,5**	XX	113	69	*13*	**12,5 ± 0,5**	XX
		II	100	45	*92*		XX	117	72	*12*		XX
» » » *b*	1	I	104	47	*86*	**86,5 ± 0,5**	XX	93	57	*0*	—	—
		II	123	55	*87*		XX	96	59	*2*		o—X
Hormonema dematioides	29	I	137	61	*88*	**89 ± 1**	XXX	130	80	*1*	**1,5 ± 0,5**	X
		II	93	42	*90*		XXX	125	76	*2*		X
Trichosporium tingens	25	I	109	49	*90*	**89 ± 1**	XXX	113	69	*41*	**32,5 ± 9,5**	XXX
		II	105	47	*88*		XXX	102	62	*24*		XXX
Hormodendrum cladosporioides	$16^{1}/_{2}$	I	99	44	*62*	**56 ± 6**	XXX	126	77	*5*	**4 ± 1**	X
		II	120	54	*50*		XXX	125	76	*3*		X
Leptographium Lundbergii	$16^{1}/_{2}$	I	94	42	*89*	**90 ± 1**	XXX	117	72	*0*		—
		II	90	40	*91*		XXX	129	79	*0*		
Cadophora fastigiata	$16^{1}/_{2}$	I	105	47	*26*	**30,5 ± 4,5**	XXX	112	68	*17*	**13 ± 4**	X
		II	94	42	*35*		XXX	112	68	*9*		X
Alternaria humicola	1	I	102	46	*76*	**77 ± 1**	XX	100	61	*36*	**29,5 ± 6,5**	o—X
		II	110	49	*78*		XX	94	57	*23*		o—X
Xylomyces I	25	I	127	57	*16*	**16,5 ± 0,5**	XX	89	54	*0*	—	—
		II	128	58	*17*		XX	107	65	*0*		
Penicillium biforme	1	I	119	54	*26*	**27 ± 1**	XX	89	54	*0*	—	—
		II	92	41	*28*		XX	107	65	*0*		—

cause any discoloration of the wood in spruce. The pine sectors, on the other hand, were more or less intensely discoloured by all species. Only in the experiments with *Leptographium* the intensity of the blueing was fairly faint, probably due to the water content of the sapwood being near the minimum for the development of the fungi.

Since in experiments made for other purposes it seemed to be apparent that the blueing fungi behaved more erratically in spruce than in pine, another series of experiments with winter-felled pine and spruce was made. In this all species isolated were tested, with the exception of *Hormodendrum microsporum*.

Test-Series 10. Winter-felled pine and spruce.

The trees were felled on the 8th December, 1925, and the tests commenced immediately thereafter. The sections had in both instances 30 rings and measured 13,5 (pine) and 14 (spruce) cm. respectively in diameter. No heartwood had developed. The pine had in the outer sapwood a water content of 175 % of dry substance (in the inner portion 162 %); the spruce 142 %. The degrees of saturation were 79 and 87 % respectively. The sectors were dried to an optimal water content, and then subjected to partial sterilisation. The tests, which were duplicated with every species, lasted for 25 days. The results are rendered in Table 13 and Plates I—II.

If we first compare the results with those obtained in Test-series 8 we notice that in some cases the same fungi behaved rather differently towards pine and spruce. In the pine-tests we find great differences only in regard to *Ceratostomella cœrulea*, *Cadophora fastigiata* and *Xylomyces* I. The two first-mentioned developed much better in Test-series 10 than in series 8. This is especially the case with *Ceratostomella cœrulea*. An important reason for this with regard to the latter might be, as mentioned above, that the ages of the inoculation-strain were so very different. In regard to *Cadophora* the cause must, however, be another. In the test with the larger percentage of blueing the inoculation-strain was as a matter of fact 9 months older than in the test with the feebler growth. *Xylomyces* I, on the other hand, had developed less in Test-series 10 than in series 8. The inoculation-strain was in the former instance $9^1/_2$ months older than in the latter. This may possibly be a contributary cause. It must, however, be pointed out that we have not been able to find any signs of degeneration in *Xylomyces* I due to prolonged culture upon an artificial substratum.

In the spruce-tests, *Endoconidiophora cœrulescens* displayed an approximately equally rapid growth in both cases; *Ceratostomella cœrulea*

and *Cadophora fastigiata*, on the other hand, an almost equally feeble growth. With respect to the other species we find a poorer development in Test-series 10 than in series 8. *Leptographium Lundbergii* and *Xylomyces* did not cause in the former any discoloration at all in the wood; *Discula pinicola, Hormonema dematioides* and *Hormodendrum cladosporioides* caused a very small percentage of blueing. This great difference does not appear to be due to any difference in the character of the inoculation-strains. Of *Discula pinicola* v. *mammosa* the one-month old strain developed even more poorly than the one two years older. The differences in the rate of growth may rather be due to difference of the chemical nature of the wood.

If we compare the pine and spruce-tests in Test-series 10 with each other we notice that with the exeption of *Endoconidiophora cærulescens* all the species developed more rapidly in the former than in the latter. The discoloration was furthermore generally more pronounced in the former case than in the latter. Exceptions to this were, besides *Endoconidiophora, Sclerophoma entoxylina* and *Trichosporium tingens*.

If the radial rate of growth for the most rapidly growing species in the test-series, *Endoconidiophora* in spruce, is designated with 100, the following relative values of growth are obtained.

	Pine	Spruce
Ceratostomella cœrulea	63	15
» *Piceæ a*	0	0
» » *b*	32	0
» *pluriannulata*	48	0
» *Pini a*	67	52
» » *b*	68	35
Endoconidiophora cœrulescens	69	100
Sclerophoma entoxylina a	68	51
» » *b*	61	43
Discula pinicola	63	8
» » v. *mammosa a*	72	9
» » » *b*	63	7
Hormonema dematioides	75	3
Trichosporium tingens	75	36
Hormodendrum cladosporioides	52	7
Leptographium Lundbergii	83	0
Cadophora fastigiata	28	9
Alternaria humicola	60	23
Xylomyces I	15	13
Penicillium biforme	16	0

As a summary of the results concerning the behaviour of the fungi in pine and spruce the following may be presented:

All species investigated develop more or less strongly in pine. To those species which develop most rapidly in pine, and cause intense discoloration under optimal conditions, belong: *Ceratostomella cœrulea*, *C. Pini*, *Endoconidiophora cœrulescens*, *Sclerophoma entoxylina*, *Discula pinicola*, *Hormonema dematioides*, *Trichosporium tingens*, *Leptographium Lundbergii*, *Alternaria humicola and Xylomyces* I. In the species growing less rapidly in pine may be included *Ceratostomella pluriannulata*, *C. Piceæ*, *Hormodendrum cladosporioides*, *Cadophora fastigiata* and *Penicillium biforme*. Of these, *Hormodendrum cladosporioides* causes the most intense discoloration.

Variations as to the intensity of growth of the fungi in pine may nevertheless occur. *Ceratostomella cœrulea*, *C. Piceæ* and *Xylomyces* I displayed the greatest variations in this respect. In certain cases they produced a very feeble growth in pine, the blueing being less extensive or absent. At least in regard to *C. cœrulea* and *C. Piceæ* the intensity of growth in wood appears to be largely dependent upon the nature of the inoculation-strain. The former caused less extensive blueing in those instances where the inoculation-strain, owing to prolonged culture, displayed a poorer growth upon malt-agar. With respect to *C. Piceæ*, it has already been pointed out (p. 183) that it behaved very differently in different tests. In Test-Series 10 blueing was caused only by the strain that had been kept in culture for $4^1/_2$ months, but not by the one kept in culture for 19 months. Like *C. cœrulea*, this species appears to become easily enfeebled by prolonged culture upon an artificial substratum, which finds expression, inter alia, in the development of graphia becoming less regular, or ceasing entirely, upon malt-agar.

Upon winter-felled spruce *Endoconidiophora cœrulescens* developed just as well as upon pine, or even better. All other blueing fungi investigated grew more poorly in spruce than in pine, even if the different species behaved in a quite different manner.

Apart from *Endoconidiophora*, the following developed best and caused blueing which in intensity of colour was not far behind that which they did in pine: *Ceratostomella Pini*, *Sclerophoma entoxylina*, *Trichosporium tingens*. Sometimes *Discula pinicola*, *Leptographium Lundbergii* and *Xylomyces* I also assumed a rapid development and caused a fairly intense discoloration. *Ceratostomella cœrulea*, *C. Piceæ*, *Hormonema dematioides*, *Hormodendrum cladosporioides*, *Cadophora fastigiata*, *Alternaria humicola*, *Xylomyces* I and *Penicillium biforme* caused a slight percentage or no blueing. In the former case the discoloration was as a rule very

faint. The two last species never caused any blueing of spruce in laboratory tests; and *Ceratostomella Piceæ* only in one instance (Table 6) produced a faint discoloration in the outermost rings.

In spring-felled spruce only *Ceratostomella cærulea* and *Cadophora fastigiata* produced an extremely faint discoloration.

The researches have thus confirmed the view that spruce on the whole is a less suitable substratum for blueing than pine. But they have on the other hand proved that the rather generally disseminated opinion as to blueing on the whole not being produced in spruce, is erroneous. The results coincide perfectly in this respect with those obtained in the practical tests (cf Part. II).

What can then be the cause of blueing fungi on the whole developing better in pine than in spruce? It is quite obvious to assume that the assimilatives of the parenchyma cells are more favourable to the fungi in the former than in the latter. As has previously been mentioned, MÜNCH (1908) made some test cultures with *Ceratostomella Pini*, *C. Piceæ*, *C. cærulea* and *Endoconidiophora cærulescens* in KNOP's nutrient solution containing various carbon-sources. He discovered in the course of these that the carbon-source is of vast importance for the development of these species in a synthetic nutrient solution. Thus, *C. Piceæ* developed best upon cane-sugar, glucose and starch; *C. cærulea* and *C. Pini* best upon starch; and *Endoconidiophora* well upon both glucose and starch.

We made an analogous test-series with 10 of our isolated species. As a substratum nutrient-agar was used (1,5 % agar-agar). The nutrient solution was of the following composition.

1,000 cm^3 destilled water,
0,5 gr KH_2PO_4,
0,5 » $MgSO_4$,
10 drops 1 % $FeCl_3$-solution,
0,5 grams NH_4NO_3.

The carbon-source, viz. starch, dextrine, maltose, glucose or olive oil, was added in a proportion of 0,5 %. A phosphate solution was used as a buffer. The concentration of hydrogen ions at the commencement of the tests was pH 5,5.

The cultures, which were made in duplicate, were kept at 22° C. The tests lasted for three weeks.

The results are summarised in Table 14. It will be seen that the majority of species developed more poorly upon all carbon-sources than upon

malt-agar. Only *Xylomyces* I showed approximately the same rate of growth as upon the latter substratum. *Endoconidiophora cœrulescens, Hormonema dematioides, Hormodendrum cladosporioides* and *Cadophora fastigiata* developed fairly well; *Ceratostomella cœrulea, C. Pini, C. Piceæ* and *Leptographium Lundbergii*, on the other hand, very feebly. *Trichosporium tingens* displayed practically no growth. With regard to the nutritive value of the various carbon-sources for the fungi, no appreciable and thorough difference was manifested. Upon oil the growth was in some instances somewhat feebler than upon other carbon-sources *(Endoconidiophora, Hormonema, Hormodendrum, Cadophora)*; in others, on the contrary, somewhat stronger than upon them *(Leptographium)*. Starch did not show any distinct superiority over other carbohydrates.

Table 14. **Growth[1] and colour[2] upon different carbon-sources after 5 weeks at 22°C. Phosphate buffer. pH at commencement of tests 5.5.**
Tillväxt och färg på olika kolkällor efter 5 veckor vid 22° C. Fosfatbuffert, pH vid försökens början 5,5.

	Starch[3] Stärkelse		Dextrine Dextrin		Maltose Maltos		Glucose Glykos		Olive Oil Olivolja	
	Growth Tillväxt	Colour Färg	Growth Tillväxt	Colour Färg	Growth Tillväxt	Colour Färg	Growth Tillväxt	Colour Färg	Growth Tillväxt	Colour Färg
Ceratostomella cœrulea	2	o—X	2	o	2	X	2	o	2	o—X
Ceratostomella Piceæ	1	o	1	o	1	o—X	1	o	1	o
Ceratostomella Pini	1	o—XX	1	o—X	1	o—X	1	o	1[4]	o—XX
Endoconidiophora cœrulescens	4	XX	4	XX	4	XX	4	XX	3[4]	XX
Hormonema dematioides ...	4	XXX	4	XXX	4	XX	4	XX	3[4]	o—XX
Trichosporium tingens	o	o	o	o	o	o	o	o	o	o
Leptographium Lundbergii..	1	XX	1	XX	1	XX	1	XX	2	XX
Cadophora fastigiata	3	X	3	X	3	X	3	X	2[4]	o—X
Hormodendrum cladosporioides .	4	XX	4	XX	4	XX	4	XX	3[4]	XX
Xylomyces I[5]...	5	XXX	5	XXX	5	XXX	5	XXX	5	XXX

[1] Compared with growth upon malt-agar which for every species is indicated with 5.
[2] Colour of mycelium indicated by means of a 3-graded scale (X—XXX).
[3] Amyl. solub. (MERCK).
[4] The hyphæ concentrated in the drops of oil which thus became more or less intensely coloured.
[5] Radial growth upon all carbon-sources used the same as upon malt-agar. Density of colonies also approximately the same as upon malt-agar.

Table 15. **Occurrence of starch in winter-felled pine and spruce inoculated with different blueing fungi (Test-series 10).**

Förekomst av stärkelse i vinteravverkat tall- och granvirke, som ympats med olika blåyte-svampar (försöksserie 10).

	Starch apparently not decimated (+) Stärkelse till synes ej decimerad		Starch clearly decimated (+) Stärkelse tydligt decimerad		Starch not found (+) Stärkelse ej påvisad		Notes Anmärkningar
	Pine Tall	Spruce Gran	Pine Tall	Spruce Gran	Pine Tall	Spruce Gran	
Ceratostomella cærulea	+	·	·	·	·	+	
» *Piceæ a*	+	·	·	·	·	+	
» » *b*	+	·	·	·	·	+	In the parenchyma cells too, which contain pycnidia, starch has been found in pine. Även i de parenkymceller, som innehålla pyknid, har stärkelse påvisats hos tall.
» *pluriannulata*	·	·	·	·	+	+	
» *Pini*	+	·	·	·	·	+	
Endoconidiophora cærulescens	·	·	·	·	+	+	
Sclerophoma entoxylina	·	·	·	·	+	+	
Discula pinicola	+	·	·	·	·	+	
» v. *mammosa*	+	·	·	·	·	+	
Hormonema dematioides	+	·	·	·	·	+	
Trichosporium tingens	+	+	·	·	·	·	
Hormodendrum cladosporioides	·	·	+	·	·	+	In those cells which are almost filled by hyphæ, starch is lacking in pine. I de celler, som nästan äro uppfyllda av hyfer, saknas stärkelse hos tall.
Leptographium Lundbergii	+	+[1]	·	·	·	·	
Cadophora fastigiata	+	·	·	·	·	+	
Alternaria humicola	·	·	·	·	+	+	
Xylomyces I	·	·	+	·	·	+	
Penicillium biforme	·	·	+	·	·	+	

It appears to be obvious from this that blueing fungi are not so specialised in regard to their carbon-sources as has hitherto been assumed. But at the same time one must draw the conclusion from the tests that certain other nutrient-factors exercise a powerful influence upon the growth of the majority of species.

One also arrives at this view by microscopic examination of wood attacked by blueing fungi. The results of an investigation into the starch and fat content[2] in pine and spruce (Test-series 10, Plates I—II) attacked by different blueing fungi, in comparison with the same in intact timber, have been summarised in Tables 15 and 16. The parenchyma cells of the pith-rays in the intact timber contained fat very

[1] Not investigated.

[2] As a reagent for fat Sudan III was used.

Table 16. **Occurrence of fat in winter-felled pine and spruce inoculated with different blueing fungi. (Test-series 10).**

Förekomst av fett i vinteravverkat tall- och granvirke, som ympats med olika blåytesvampar (försöksserie 10).

	Fat apparently not decimated (+) Fett till synes ej decimerat		Fat greatly decimated (+) Fett tydligt decimerat		Fat not found (+) Fett ej påvisat		Notes Anmärkningar
	Pine Tall	Spruce Gran	Pine Tall	Spruce Gran	Pine Tall	Spruce Gran	
Ceratostomella cærulea	•	+	+	•	•	•	Fat occurs in the spruce in the form of irregular films upon the walls of the hyphæ.
» *Piceæ a*	+	+	•	•	•	•	
» » *b*	•	+	•	•	+	•	
» *pluriannulata*	•	+	+	•	•	•	
» *Pini*	•	+	+[1]?	•	•	•	
Endoconidiophora cærulescens	+	•	•	+	•	•	Fett förekommer i granvirket som oregelbundna beläggningar på hyfernas väggar.
Sclerophoma entoxylina	•	•	•	•	+	+	
Discula pinicola	+	+	•	•	•	•	The fat in spruce distributed in numerous minute drops. Fettet i granvirket fördelat i talrika droppar.
» *v. mammosa*	+	+	•	•	•	•	
Hormonema dematioides	•	+	+	•	•	•	
Trichosporium tingens	+	+	•	•	•	•	
Hormodendrum cladosporioides	•	+	+	•	•	•	
Leptographium Lundbergii	+	+	•	•	•	•	
Cadophora fastigiata	•	+	+	•	•	•	
Alternaria humicola	+	+	•	•	•	•	
Xylomyces I	•	•	•	+	+	•	
Penicillium biforme	•	+[1]?	•	•	+	•	

abundantly. Starch was fairly plentiful in some cells; in others, on the contrary, in an insignificant degree. In the spruce there was likewise present an abundance of fat (yet less was present than in the pine). Starch occured fairly sparsely.

It is obvious from Table 15 that the fungi on the whole behaved differently towards the starch of the parenchyma cells in pine and spruce. In the pine only 4 species, viz.: *Ceratostomella pluriannulata*, *Endoconidiophora cærulescens*, *Sclerophoma entoxylina*[2] and *Xylomyces* I, completely destroyed the starch, while in the spruce this was the case with at least 7 more species. Of the fungi that are more active in spruce, only *Trichosporium tingens* has left the starch entirely untouched. At

[1] Not investigated.

[2] As mentioned above (cf. p. 208), *Sclerophoma entoxylina* also used the cellulose of the walls of the cells as a carbon-source. The walls of the parenchyma cells had been entirely dissolved.

least for the majority of species the starch appears thus not to be necessary as a carbon-source in order that optimal development may be attained.

Most of the species acted more on the fat of the parenchyma cells in pine than in spruce (Table 16), although only 4 species, viz. *Ceratostomella Piceæ (b)*, *Sclerophoma entoxylina*, *Xylomyces* I and *Penicillium biforme* had completely decomposed the same. Of the 15 species examined, five had not noticeably utilised the fat in pine as a carbon-source. Amongst these ware several of the most active blueing fungi, viz. *Endoconidiophora cærulescens*, *Discula pinicola*, *Trichosporium tingens* and *Leptographium Lundbergii*. In spruce, only *Sclerophoma entoxylina* had completely decomposed the fat; of the others, 11 have not noticeably attacked the same. Among the latter there are two of the fungi which in the test were found to be more active on spruce, viz. *Ceratostomella Pini* and *Trichosporium tingens*.

The fat of the parenchyma cells in pine has thus been utilised as a carbon-sourse by the majority of species, while this has on the whole not been the case in spruce.

In order to be able to understand properly the cause of the somewhat different behaviour of the fungi towards starch and fat in pine and spruce, a thorough physiologial investigation is necessary. Before this has been made, it can only be stated that most of the species behave differently in pine and spruce. To what this is due, can, however, not be decided with any certainty.

The microchemical examination appears to confirm the results obtained by the aforesaid culture-test, viz. that the blueing fungi as a rule are not strictly specialised in regard to carbon-source. They are neither pronounced fat-fungi nor starch-fungi.[1]

It ought to be specially pointed out that *Discula pinicola*, *Trichosporium tingens* and *Leptographium Lundbergii* have not noticeably attacked either starch or fat in pine despite the parenchyma cells frequently being filled with hyphæ. For these the protoplasm of the cells very likely formed the chief source of carbon.

Several things argue in favour of the view that for most of the other species also the protoplasm of the parechyma cells greatly influences the intensity of development. In the pine as a rule both protoplasm and nuclei have gradually been entirely consumed. Specially interesting in this respect is *Ceratostomella cærulea*. This latter forms, as has been previously mentioned (cf. fig. 6, p. 170), peculiar balls of hyphæ in the

[1] How the sugar content of the parenchyma cells affects the development of the fungi, has not been investigated.

parenchyma cells. Probably these have developed around the nuclei which have afterwards been entirely consumed. In the spruce the plasma of the parechyma cells had been more or less completely destroyed by only the most active species, such as *Ceratostomella Pini*, *Sclerophoma entoxylina* and *Trichosporium tingens*.

It is further possible that at least certain species, e. g. *Trichosporium tingens*, are stimulated by phosphatides of the protoplasm, analogous with the mycorrhizal fungi of the trees (MELIN 1925). As mentioned before, this species does not grow upon autoclave-sterilised wood, which may possibly be due to the phosphatides having become inactive by heating. It is our intention to take up this question for investigation later on.

From the aforesaid it will be seen that probably it is not the nature of the assimilatives which makes spruce on the whole less favourable for the blueing fungi than pine. The source of the real cause must for the present be left undecided. It is possible that the protoplasm of the parenchyma cells in the spruce is less tempting for the fungi than that in pine. But it is also possible that the spruce contains certain substances which are detrimental to the fungi, and retard the progress of the hyphæ.[1] That certain blueing fungi behave rather erratically towards spruce might be explained in accordance with these theories by the assumption that the character of the protoplasm varies, or that the supposed antiseptic substances in some instances occur in larger quantities than in others.

2. Time of felling and development of blueing fungi.

It is often considered amongst foresters that timber felled during spring and summer is more liable to blueing than that felled in winter. One encounters this opinion not only in Sweden. In the United States, for example, the same opinion is generally prevalent, and the most favourable time for felling is therefore also in that country considered to be the autumn and winter (HOWARD 1922).

HOWARD considers the cause of the supposedly different behaviour of the blueing fungi in timber felled at different times to be that the supply of nutriment is more favourable for the fungi in timber felled

[1] It may be assumed that a different rate of diffusion of the oxygen in pine and spruce may play a certain part for the different intensity of development of the blueing fungi. It is a well-known fact that spruce on being stored in spring absorbs water much more slowly than pine. By way of example, spruce is always used for pontoon bridges and other floating structures, e. g. intakes and booms. It has furthermore been known of old that spruce is more difficult to impregnate than pine. An investigation into the rate of diffusion of the oxygen in different kinds of wood would be highly desirable.

during spring and summer than in that felled in winter. In the former case the sapwood contains a more or less plentiful supply of sugar favourable to the fungi; in the latter instance, on the contrary, it contains, inter alia, starch and gums which would be less advantageous carbon-sources (HOWARD l. c. p. 21).

We have not had an opportunity to carry out a comparative simultaneous, quantitative research into the assimilatives in pine and spruce felled in winter-time and then stored in the open air, and in timber felled in spring and summer. It is probable that certain dissimilarities as to assimilatives exist, even assuming that also in winter-felled timber the fat and starch to a certain extent are mobilised on the appearance of a higher temperature in spring. This does, however, not prove that the condition of the assimilatives in the one instance is more favourable than in the other. From what has been previously stated regarding the behaviour of the fungi towards various carbon-sources it is, on the contrary, probable that such is not the case.

The previously given Test-series 8 and 9 illustrate in a certain measure the question as to whether the timber felled in spring is more favourable to the fungi from a nutritive point of view than that felled in winter. The timber used in the said tests was, as has been mentioned, cut in January and the end of April, 1925. The tests were started immediately after the trees had been felled.

With regard to the pine (Tables 9 and 10) we find that *Endoconidiophora cærulescens* and *Xylomyces* I developed more poorly in the spring than in the winter tests. *Trichosporium tingens* and *Hormonema dematioides* developed almost equally well in both cases, while *Ceratostomella cærulea* and *Cadophora fastigiata*, on the contrary, had a more rapid growth in the spring than in the winter-felled timber. In regard to *Discula pinicola*, *Hormodendrum cladosporioides* and *Leptographium Lundbergii* no safe comparisons can be drawn, inasmuch as the sectors in the spring-test had a water content which — at least for the two last-mentioned species — was somewhat lower than the optimal.[1]

With respect to the spruce the blueing capacity for all species was considerably less in the spring-felled than in the winter-felled timber. Most of the species in the spring-tests caused practically no blueing, and in the cases where such occurred *(Ceratostomella cærulea, Cadophora fastigiata)* it was extremely faint, which goes to prove that the hyphæ were greatly impeded in their development.

[1] In the spring-test with *Hormonema dematioides* the water content was also very low (32 % I). As, however, the blueing after three weeks had reached the sapwd (91 % of 00 the sector) it is assumed that the growth was optimal, or very nearly so.

The following series of tests was also carried out with pine felled at various times.

Test-Series 11. Winter- and spring-felled pine, Dalecarlia, Garpenberg. Timber from 5 different trees, 3 broad-ringed and 2 close-ringed, was investigated. The trees were felled in the month of February and on the 15th June, 1926, respectively. The winter-felled timber was lying in the open air until the last-mentioned date, after which the tests were commenced simultaneously both with this and the freshly felled timber.

The nature of the timber will be seen from Table 17.

Table 17. **Timber used in Test-Series 11.**
Det i försöksserie 11 använda virket.

	Diameter	Age, years Ålder år	Sapwood mm. Splint mm	Width of rings in sapwood (average) mm. Årsringsbredd i splinten (medeltal) mm	Water capacity of dry substance % Vattenkapacitet av torrsubstans %
Winter-felled *a* ..... Vinteravverkad	150	44	49—54	1,6	183
b	120	55	40—42	0,8	157
Summer-felled *a* ..... Sommaravverkad	165	31	50—55	2,1	217
b	130	22	42—50	3,0	231
c	85	81	28—32	0,6	129

The sectors were dried to an optimal water content, after which they were partially sterilised. The tests lasted three weeks.

The results are summarised in Table 18. On account of the different size of sectors the radial extent of the blueing was taken as a gauge for the rate of development of the fungi. The hyphæ had in all instances penetrated fairly uniformly from the tangential surfaces.

It is obvious from Table 18 that thorough uniformity in the behaviour of the fungi in winter- and summer-felled pine could not be proved. *Ceratostomella Pini* and *Leptographium Lundbergii* eluded comparison, inasmuch as the entire sapwood had become permeated in the course of the tests. Of other species, *Discula pinicola*, *Trichosporium tingens* and *Hormodendrum cladosporioides* developed better in the broad-ringed wood in the winter-felled than in the summer-felled. *Xylomyces* I caused discoloration only in the former, although to a very limited extent. Other species examined developed almost equally in both cases. In the close-ringed wood the condition was partly different. *Ceratostomella cærulea* displayed a poorer growth in the summer-felled than in the winter-felled

Table 18. **Blueing intensity of fungi in winter- and summer-felled, broad-ringed and close-ringed pine. Average of two parallel tests. Test-period three weeks. Normal room temperature.**

Blåytesvamparnas blånadshastighet i vinter- och sommaravverkad, frod- och senvuxen tall. Medeltal av två parallellförsök. Försökstid tre veckor. Rumstemperatur.

	Number of months in pure culture Ympstammens antal månader i kultur.	Water content of sapwood Splintens vattenhalt		Blueing Blånad		Water content of sapwood		Blueing Blånad		Water content of sapwood		Blueing Blånad	
		I %	II %	Radial growth mm. Radiär tillväxt	Colour Färg	I %	II %	Radial growth mm. Radiär tillväxt	Colour Färg	I %	II %	Radial growth mm. Radiär tillväxt	Colour Färg
A. Broad-ringed pine:		Winter-felled *a* Vinteravverkad				Summer-felled *a* Sommaravverkad				Summer-felled *b* Sommaravverkad			
Frodvuxen tall:													
Ceratostomella cærulea	10[1]/2	45	25	**35**	XXX	93	43	**36**	XX	100	43	**33**	XXX
» *Pini*	8[1]/2	60	33	**54**[1]	XXX	89	41	**51**[1]	XXX	90	39	**42**[1]	XXX
Discula pinicola v. *mammosa*	3[1]	75	41	**48**	XXX	81	37	**38**	XXX	153	66	**24**	X–XX
Hormonema dematioides	35	74	40	**49**[1]	XXX	111	51	**44**	XXX	88	38	**47**[1]	XXX
Trichosporium tingens	3[1]	54	29	**51**[1]	XXX	90	41	**48**	XXX	122	53	**39**	XXX
Hormodendrum cladosporioides	22[1]/2	64	35	**19**	XXX	103	48	**12**	XXX	111	48	**0**	o
Leptographium Lundbergii	22[1]/2	60	33	**52**[1]	XXX	91	42	**55**[1]	XXX	80	35	**49**[1]	XXX
Cadophora fastigiata	22[1]/2	65	35	**13**	XX	108	50	**0**	o	77	33	**16**	XX
Xylomyces I	3[1]	72	39	**4**	XX	106	49	**0**	o	100	43	**0**	o
B. Close-ringed pine:		Vinter-felled *b* Vinteravverkad				Summer-felled *c* Sommaravverkad							
Senvuxen tall:													
Ceratostomella cærulea	10[1]/2	80	51	**32**	XXX	38	29	**14**	XX	—	—	—	—
» *Pini*	8[1]/2	70	44	**40**[1]	XXX	47	36	**32**[1]	XXX	—	—	—	—
Discula pinicola v. *mammosa*	3[1]	100	64	**24**	XXX	39	30	**26**	XXX	—	—	—	—
Hormonema dematioides	35	84	54	**31**	XXX	50	39	**32**[1]	XXX	—	—	—	—
Trichosporium tingens	3[1]	46	29	**29**	XXX	46	36	**28**[1]	XXX	—	—	—	—
Hormodendrum cladosporioides	22[1]/2	97	62	**0**	o	50	39	**17**	XXX	—	—	—	—
Leptographium Lundbergii	22[1]/2	70	45	**10**	XX	63	49	**12**	XX	—	—	—	—
Xylomyces I	3[1]	66	42	**0**	o	35	27	**0**	o	—	—	—	—

[1] Sapwood limit reached.

timber. *Hormodendrum*, on the other hand, caused blueing only in the summer-felled timber. *Xylomyces* I, on the whole, did not penetrate into the timber. *Discula pinicola*, *Trichosporium tingens* and *Cadophora fastigiata* developed almost equally in both instances.

The results recorded therefore do not give any suport to the view that spring and summer-felled pine and spruce should be more favourable from a nutritive point of view for the development of the fungi than winter-felled timber.

With regard to spruce, they speak as a matter of fact against this view. Nevertheless it is naturally premature to draw any general conclusions in this respect from a single test, especially as spruce, as has been pointed out in the preceding, forms a fairly erratic substratum for the fungi.

Nor have our practical experiments recorded in Part II, which were also intended to illustrate the importance of the time of felling for the development of the blueing fungi in round timber, given any support to the view that the spring- and summer-felled timber is more favourable from the point of view of nutrition than that felled in winter. In the said tests the time of felling affected the development of blueing only in so far as the water content of the timber during the optimal period for the blueing fungi could cause the same.

There has as a matter of fact on the whole existed a parallelism between the degree of drying of the timber and the intensity of blueing, something which is especially manifest in respect to pine. In the timber which has been stored under conditions allowing rapid drying (decorticated, stacked in a triangle) the blueing fungi reached the most rapid development where the water content was lowest during the summer. It should, however, be observed that the blueing on the whole has had a more intense colour in the summer than in the winter-felled pine. This condition may possibly be due to various species of fungi having been active in the different cases. But this has not been proved by direct research.

In those storage-tests where drying was less rapid, the blueing was in the main of very small extent. Some interesting exceptions may, however, in this respect be noted. With regard to the pine which had been stripe-wise stripped, and stacked in a triangle, the blueing was on the whole rather slight in such as had been felled before the month of June; it was, on the other hand, somewhat larger in that felled during the period from the 15th June to the 1st July. Of the pine which was not decorticated and had been stored on the ground, that felled between the 15th June and 15th August showed a relatively large

percentage of blueing, whereas the latter in the earlier felled timber was on the whole remarkably slight, or absent. It is of particular interest to find that the loss of water in the timber during the summer in the last-mentioned case was very slight. This suggests that the original water content in the timber under certain circumstances is able to play a part in the rapidity of development of the blueing fungi.

From HARTIG's (1882) researches it seems that the water content of the sapwood in the living tree is not constant throughout the year. Of coniferous trees examined, at least in pine (South Germany), it was much less during the spring and early summer than in winter.

As far as Sweden is concerned no researches have previously been made into the water content of the living tree at different seasons of the year. In connection with our studies of the behaviour of blueing fungi in timber one of us (LUNDBERG) therefore made an investigation into the water content of the wood of pine *(Pinus silvestris)* and spruce *(Picea excelsa)* during one year. For this purpose four approximately 100-year old, relatively free-standing trees, 2 pines and 2 spruces, were selected in the park of the College of Forestry at the Experimentalfältet (Stockholm). The investigation was commenced on the 28th October, 1924, and once a week the water-tests were carried out until the same date in 1925. The water-tests were made by taking borings from time to time within the same rings.[1] The borings were chiefly taken perpendicularly below each other, beginning at the top, to obviate, if possible, interference in the water supply from the roots.

The results are recorded in fig. 85 and 86. The values forming the basis for the pine-curves (fig. 85) are average ones from the two pine trees examined, whereas the spruce-curves are based upon values from one tree. The water content of the outer and inner sapwood was ascertained separately only in the tree on which the curve drawn in fig. 86 is based. In the other spruce the water content of the entire sapwood was measured without distinguishing the different layers. The curve obtained in the latter instance was, however, very similar to that in fig. 86.

We find that the curves on the whole follow approximately the same course in pine and spruce. The water content of the sapwood was in both cases lowest during the summer months. During May and in the beginning of June a great drop in the water content took place. This

[1] The water content ascertained by borings is slightly lower than the actual. The error caused by this method is, however, of no very great importance for the present investigation. Thorough investigations into this source of error in water tests with timber will be published by »The Committee for Research into the Floatability of Timber».

drop was greatest in the spruce, which during June had attained a water content of about 60 % of the dry substance, i. e. only about 30 % of the maximal. The water content of the pine droped to about 110 %, i. e. about 70 % of the maximal. The great loss of water was naturally due to the transpiration being greater than the absorption of water through the roots. That the water content of the spruce droped more than that of the pine, was probably due to the former's relatively greater mass of needless. The pine retained its water content fairly unchanged

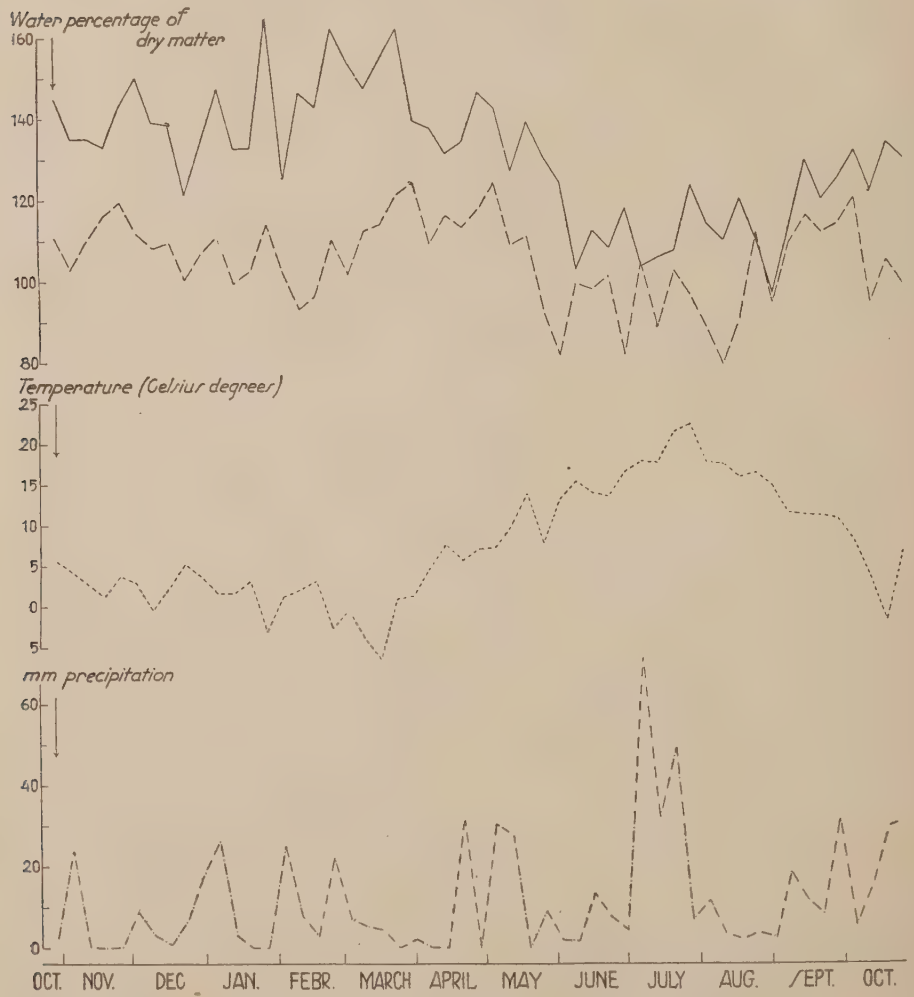


Fig. 85. Water content in the sapwood of living pine *(Pinus silvestris)* during one year. Outer (——) and inner (— — —) sapwood.

Vattenhalten i splinten hos växande tall *(Pinus silvestris)* under ett år. Yttre (——) och inre (— — —) splint.

during the summer months, after which, during the autumn, it was increased by 140 %. The water content of the spruce appears during the summer

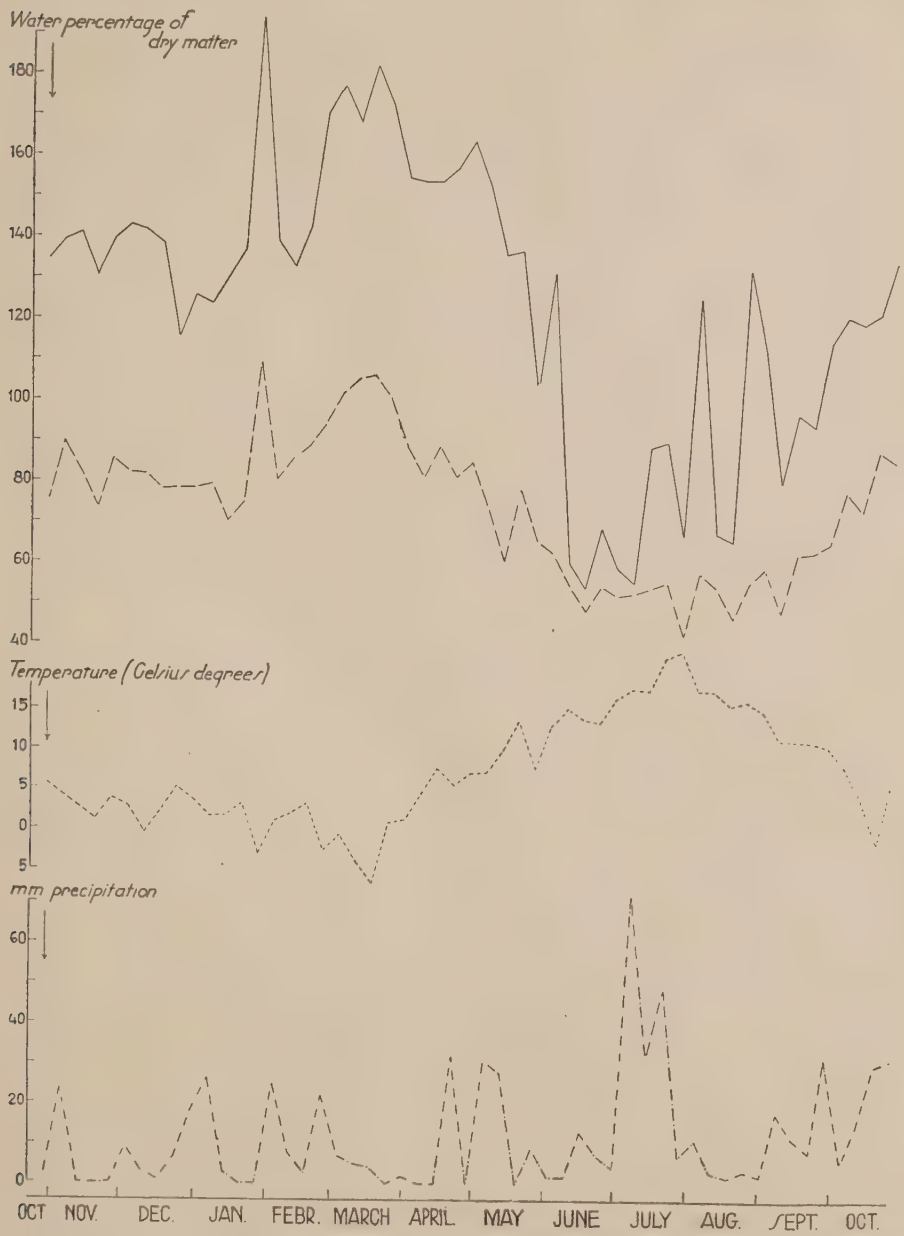


Fig. 86. Water content in the sapwood of living spruce *(Picea excelsa)* during one year. Outer (——) and inner (— — —) sapwood.

Vattenhalten i splinten hos växande gran *(Picea excelsa)* under ett år. Yttre (——) och inre — — —) splint.

to be more influenced by the changes in precipitation than that of the pine; from September it rose fairly rapidly towards its maximum.

It will thus be seen that the water content in the sapwood is very largely influenced by, inter alia, precipitation and temperature of the air, i. e. factors which regulate transpiration and absorption of water. Even if for that reason we are unable to generalise the results, it may yet be said that the water content of the sapwood on the whole is considerably lower in summer than in winter. This is especially the case during dry summers.

It seems quite obvious that the water or oxygen content respectively of the timber may be comparatively favourable for the fungi in summer-felled timber already immediately after felling. To a very high degree this holds good during very dry summers. The negative pressure is then perhaps fairly great in the sapwood of the tree on the roots owing to the great evaporation. On felling, air therefore forces its way in, making the supply of oxygen rather favourable. Even if the oxygen content is far from optimal for the majority of species, it is no doubt considerably greater than in winter-felled timber that has been stored under conditions which exclude a loss of water. More rapid growth can therefore take place in the former than in the latter timber. For *Ceratostomella Pini*, which is less exacting in regard to oxygen, the oxygen content in summer-felled pine-timber may in some instances even be sufficient for optimal intensity of growth.

In winter-felled timber, on the other hand, which has been stored under conditions which have permitted of rapid drying, the water or oxygen content respectively may become more favourable at the beginning of summer than in timber freshly felled at this period. This finds expression in greater rapidity of blueing in winter-felled than in summer-felled timber.

By way of summary of the tests carried out concerning the effect of the felling-period upon the development of the blueing fungi, the following may be said. The spring- and summer-felled pine and spruce is from a nutritive point of view no more favourable for the blueing fungi than the winter-felled. In those cases where one is able to prove more intense blueing in the summer-felled than in the winter-felled timber, this may chiefly be due to the water content being more favourable to the fungi in the former than in the latter.

3. Development of the blueing fungi in timbers of different density.

With regard to wood destroying fungi, several investigators have found that the density of the rings plays an important part in the rapidity of growth of the hyphæ in the timber. One of us (LAGERBERG 1919) discovered, for example, that the decay occurring in top-fractures of spruce frequently developed much more rapidly in broad-ringed than in close-ringed trees. SNELL (1921) who investigated the growth of five wood destroying fungi in timbers with different water contents, discovered that the upper and lower limits for the growth are situated at a higher or lower water content respectively in broad-ringed than in close-ringed wood.

As regards the blueing fungi, the idea seems to prevail amongst foresters that they develop much more slowly in close-ringed than in broad-ringed timber.

The above-cited Test-series 11 is an illustration of the behaviour of the fungi at an optimal water content in pine of varying density. Of the winter-felled timber the trunk *a* had twice as thick annual rings as *b*; of the summer-felled *a* had $3^{1}/_{2}$ times and *b* 5 times as thick rings as *c*.

On drawing a comparison between the tests made with the different kinds of timber in Table 19 we find that the growth throughout was not less rapid in the close-ringed than in the broad-ringed. *Ceratostomella Pini* and *Leptographium Lundbergii* escape comparison, inasmuch as the entire sapwood had been permeated in all cases. Of the other species, *Ceratostomella cærulea* and *Cadophora fastigiata* had in the winter-felled timber only a slightly greater rapidity of growth in the broad-ringed than in the close-ringed wood, while *Discula pinicola*, *Hormonema dematioides* and *Trichosporium tingens* developed much more rapidly in the former than in the latter. *Hormodendrum cladosporioides* and *Xylomyces* I caused discoloration only in the former kind of wood.

In the summer-felled timber the relation between the rapidity of growth of the fungi and the width of the rings in the timber was less regular. *Ceratostomella cærulea* developed more than twice as quickly in the broad-ringed *a* and *b* timber than in the close-ringed *c* timber. *Discula pinicola* certainly had a better growth in *a* than in *c* timber, in the latter, however, slightly greater than in the broad-ringed *b* timber. In *c* it had penetrated 59 rings, as against 10 in *b*. *Hormodendrum cladosporioides* had a more rapid growth in the close-ringed timber than in the broad-ringed *a* timber; in the *b* timber, however, it had not caused any disco-

Table 19. **Radial growth of blueing fungi in broad-ringed and close-ringed pine. Test-period three weeks. Normal room temperature. For the nature of the timber see Table 17.**

Blåytesvamparnas radiala tillväxt i frod- och senvuxet tallvirke. Försökstid tre veckor. Rumstemperatur. Angående virkets beskaffenhet se tab. 17.

	Blueing in a radial direction. Blånad i radiär riktning					Blueing in number of annual rings. Blånad i antal årsringar				
	Winter-felled. Vinter-avverkat		Summer-felled. Sommaravverkat			Winter-felled. Vinter-avverkat		Summer-felled. Sommaravverkat		
	a	*b*	*a*	*b*	*c*	*a*	*b*	*a*	*b*	*c*
	Broad-ringed. Frodvuxen	Close-ringed. Senvuxen	Broad-ringed. Frodvuxen	Broad-ringed. Frodvuxen	Close-ringed. Senvuxen	Broad-ringed. Frodvuxen	Close-ringed. Senvuxen	Broad-ringed. Frodvuxen	Broad-ringed. Frodvuxen	Close-ringed. Senvuxen
	mm.	mm.	mm.	mm.	mm.					
Ceratostomella cærulea ...	35	32	36	33	14	27	42	19	14	26
» *Pini*	54[1]	48[1]	51[1]	42[1]	32[1]	38[1]	47[1]	24[1]	18[1]	59[1]
Discula pinicola v. *mammosa*	48	24	38	24	26	31	37	22	10	59
Hormonema dematioides ...	49[1]	31	44	47[1]	32[1]	32[1]	43	26	18[1]	57[1]
Trichosporium tingens ...	51[1]	29	48	39	28	34[1]	36	24	16	59[1]
Leptographium Lundbergii	52[1]	42[1]	55[1]	49[1]	28[1]	33[1]	46[1]	26[1]	19[1]	59[1]
Cadophora fastigiata ...	13	10	0	16	12	11	17	0	8	25
Hormodendrum cladosporioides	19	0	12	0	17	16	0	7	0	32
Xylomyces I	4	0	0	0	0	0	0	0	0	0

loration. *Cadophora fastigiata* certainly developed somewhat more rapidly in *b* than in *c*, but had on the other hand not penetrated into *a* at all. *Xylomyces* I had in no instance penetrated into the summer-felled timber. *Hormonema dematioides* and *Trichosporium tingens* had reached the sapwood limit in the *c* timber, because of which no comparison can be made as to their growth in close-ringed and broad-ringed timber.

With regard to the summer-felled timber in Test-Series 11, it is also of some interest to compare the development of the fungi in *a* and in *b*. In the latter timber, which was broader-ringed, the rate of growth was for various species less than in the former.

From the test it seems evident that at least the majority of blueing fungi investigated under otherwise optimal conditions, also develop rapidly in pine-timber with great density of annual rings. Even if in some instances the rapidity of development was less in close-ringed than in broad-ringed pine, this was not the case throughout.

[1] The fungus has penetrated to the sapwood limit.

It seems probable to us that the density of the timber, at least as regards the pine, has in itself no great influence upon the speed of penetration of the blueing fungi, which is also quite explicable, since the hyphæ grow chiefly in the pith-rays. The chemical differences which often accompany any great dissimilarities in the density of the rings may possibly play a minor part.

The behaviour of the blueing fungi towards spruce with different density was not investigated. It is probable that at least those species which develop slowly in broad-ringed timber are further impeded, or do not penetrate into closed-ringed timber at all.

4. Behaviour of the fungi towards floated timber.

It is of particular interest to the owners of lumber-yards to ascertain whether floated timber is attacked in an equally high degree by the blueing fungi as fresh timber. Practical experience speaks in many instances in favour of such not being the case. No investigations have, however, been made in order to confirm this, if we except those carried out by MALENKOVIC (1907) and JANKA (1907). These investigators proved that timber which has been immersed in water is attacked less violently by moulds than fresh timber.

In the Test-series 6 and 7 it was seen that air-dried, immersed timber forms a poorer substratum for the majority of the fungi investigated than fresh timber. Already from this we may assume that floated timber is fairly unsuitable for a large number of species.

Hitherto one series of tests has been made with floated pine and spruce. This came from the Dalälven River and had been lying in the water from the beginning of May until the beginning of October[1] in the same year.

The pine, which was broad-ringed, had a water content (I) in the sapwood of 201 % and in the heartwood 122 %. The spruce had much narrower rings and a water content (I) in the sapwood of 159 %, and in the heartwood 106 %.

Both the pine and spruce were rather severely attacked by blueing fungi on some parts of the surface. From the blued portions *Cadophora fastigiata* and *Ceratostomella Piceæ* were isolated.

The sectors were taken from unattacked, or only slightly attacked, portions, the outermost rings being cut away. They were subjected to partial sterilisation. For the sake of control unsterilised sectors were also used.

[1] The timber was obtained from The Dalecarlian Timber Floating Association.

The tests lasted 40 days. The results have been summarised in Table 20.

In the partially sterilised sectors only three out of eight species investigated caused blueing, viz. *Ceratostomella cœrulea*, *Hormonema dematioides* and *Xylomyces* I. The first-mentioned was inoculated upon pine; the two latter on spruce. It may, however, be pointed out that *Ceratostomella cœrulea* only penetrated into one out of six sectors. In the remaining cases minor colonies had certainly developed upon the tangential surface around the inoculated conidia, but the hyphæ had penetrated only into the outermost ring. This shows that the hyphæ are able to grow only with difficulty in the timber. Of the remaining five species, *Discula pinicola*, *Leptographium Lundbergii* and *Trichosporium tingens* had not germinated. The conidia of *Ceratostomella Piceæ* and *Endoconidiophora cœrulescens* had given rise to small colonies upon the tangential surface, but no discoloration in the wood had resulted.

As far as the unsterilised sectors are concerned, more or less intense blueing had been caused, in most instances, by species which had been discovered in the timber at the beginning of the test unless the water content was too high. This blueing was frequently confined to the inner portions of the sapwood, whereas the outer sapwood as a rule was not discoloured. Right up to 48 % (pine) and 55 % (spruce) of the sectors were permeated and discolored. Of the fungi isolated from the floated timber only *Cadophora fastigiata* in this connection played any great part. The inoculated species, on the contrary, developed very poorly. Even those species which in the partially sterilised timber had caused intense blueing, displayed an extremely slow growth, evidently owing to the competition with micro-organisms previously present in the timber.

To judge from the tests carried out, different blueing fungi behave differently towards timber immersed for a long time. Some of the more sensitive species cannot develop in the same, whereas others cause distinct blueing. Of the latter some (e. g. *Ceratostomella cœrulea*) appear to grow more slowly in floated than in non-floated timber; others, on the contrary, develop almost equally well in both. Amongst the latter are *Hormonema dematioides*, *Cadophora fastigiata* and *Xylomyces* I.

The reasons for the floated timber being particularly unfavourable for some species, might be several.

Some salts and other nutritive substances important to the fungi have naturally been decreased, partly through soaking, and partly by the activity of micro-organisms, reducing the nutrient value of the timber

Table 20. **Development of blueing fungi in floated pine and spruce-timber. A. Sectors partially sterilised. B. Sectors unsterilised. Normal room temperature. Test-period 40 days.**

Blåytesvamparnas utveckling i flottat tall- och granvirke. A. Sektorerna partiellt steriliserade. B. Sektorerna ej steriliserade. Rumstemperatur. Försökstid 40 dygn.

Fungus Svamp		Number of months in pure culture Ympstammen i renkultur sedan mån.	Kind of wood Trädslag	Paraffined sectors Sektorerna paraffinerade				Non-paraffined sectors Sektorerna ej paraffinerade			
				Water content Vattenhalt			Blueing Blånad	Water content Vattenhalt			Blueing Blånad
				I %	II %	% of sector % av sektorn	Colour Färg	I %	II %	% of sector % av sektorn	Colour Färg
Ceratostomella cærulea	A.	13	Pine Tall	100	50	**9**	X	108	54	**0**	o
			»	65	52	**0**	o	43	21	**0**	o
			»	33	16	**0**	o	35	17	**0**	o
	B.		»	182	91	**0**	o[1]	130	65	**0**[2]	o
Discula pinicola v. *mammosa*	A.	13	Pine Tall	110	55	**0**	o	109	54	**0**	o
			»	59	29	**0**	o	58	29	**0**	o
			»	49	24	**0**	o	48	24	**0**	o
	B.		»	141	70	**0**	o	157	78	**0**[3]	o
Trichosporium tingens	A.	13	Pine Tall	145	72	**0**	o	130	65	**0**	o
			»	50	25	**0**	o	39	19	**0**	o
			»	29	14	**0**	o	37	18	**0**	o
	B.		»	142	71	**0**	o	149	74	**0**[4]	o
Leptographium Lundbergii	A.	4½	Pine Tall	72	36	**0**	o	54	27	**0**	o
			»	54	27	**0**	o	48	24	**0**	o
			»	41	20	**0**	o	31	15	**0**	o
	B.		»	175	87	**0**	o	130	65	**0**[5]	o
Ceratostomella Piceæ	A.	7	Spruce Gran	86	54	**0**	o	85	53	**0**	o
	B.		»	51	32	**0**	o	69	43	**0**	o
Endoconidiophora cærulescens	A.	10½	Spruce Gran	71	45	**0**	o	42	26	**0**	o
	B.		»	66	42	**0**[6]	o	48	30	**0**[7]	o
Hormonema dematioides	A.	17	Spruce Gran	86	54	**29**	X	56	35	**43**	X
	B.		»	91	57	**0**[8]	o	85	53	**0**	o
Xylomyces I	A.	17	Spruce Gran	66	42	**27**	XX	71	45	**37**	XXX
	B.		»	62	39	**0**[9]	o	99	62	**14**	XXX

[1] Small colony of *Ceratostomella cærulea* upon tangential surface, the outermost ring below this blued.

[2] Blueing by another fungus in the inner portion of the sapwood (36 % of sector).

[3] Blueing by another fungus in the inner portion of the sapwood (48 % of sector).

[4] Blueing by another fungus in the inner portion of the sapwood (30 % of sector).

[5] Blueing by another fungus in the inner portion of the sapwood (26 % of sector).

[6] *Endoconidiophora* not germinated; blueing by another fungus (55 % of sector).

[7] *Endoconidiophora* not germinated; blueing by another fungus (35 % of sector).

[8] Blueing by another fungus (46 % of sector); *Hormonema* has formed a small colony upon the tangential surface.

[9] Blueing by another fungus in the inner portion of the sapwood (32 % of sector).

for the fungi.[1] Furthermore, probably micro-organisms, chiefly bacteria, which had lived upon the surface of the timber and in its interior, produced certain toxic substances which prevented or impeded the penetration of some blueing fungi.

SUMMARY.

1. Our researches have shown that the majority of the practically important blueing fungi belong to the *Sphæropsidaceæ* and *Hyphomycetes*. The role which had previously been ascribed to species of the *Ceratostomataceæ (Cerastostomella-* and *Endoconidiophora*-species) has obviously been exaggerated.

2. Of blueing fungi proper, we have isolated and closely investigated 16 species and forms, of which 5 belong to the *Ceratostomataceæ*, 3 to the *Sphæropsidaceæ* and 8 to the *Hyphomycetes*. Moreover, a species of *Penicillium* has been isolated from timber, and this species, thanks to a plentiful development of conidia within the wood, is able to cause distict blueing.

3. As Swedish blueing fungi belonging to the *Ceratostomataceæ* we have recorded the following species: *Ceratostomella cærulea* Münch, *C. Piceæ* Münch, *C. pluriannulata* Hedgcock, *C. Pini* Münch and *Endoconidiophora cærulescens* Münch. Of these, *C. pluriannulata* has previously been quoted for North America.

4. Among the *Sphæropsidaceæ* are represented the genera *Discula* and *Sclerophoma*, the former by *D. pinicola* (Naumow) Petrak and the variety *mammosa* discerned by us, the latter by *S. entoxylina* n. sp. *D. pinicola*, recently described from Russia, was previously unknown as a blueing fungus.

5. Of the *Hyphomycetes* investigated we have considered ourselves forced to set up 3 forms as types for new genera, viz. *Hormonema dematioides* nov. gen. et sp. (= »*Dematium pullulans*» de Bary et Loew), *Leptographium Lundbergii* nov. gen. et sp., and *Cadophora fastigiata* nov. gen. et sp. Amongst the remainder, *Trichosporium tingens* and *Hormodendrum microsporum* have been described as new. *Alternaria*

[1] That some nutritive substances tempting for the blueing fungi have actually been washed out on immersing the fresh timber, could be directly proved. Pieces of fresh pine were laid in closed jars with water. After a month the entire surface of the water was covered with a dense layer of hyphæ, which largely consisted of *Ceratostomella cærulea* and *C. Piceæ*, with enormous numbers of graphia and perithecia.

humicola Oudemans known as a humus-fungus also belongs to the blueing fungi. The same holds good for *Hormodendrum cladosporioides*, and for a sterile mycelium which we have provisionally named *Xylomyces* I, and which probably belongs to the *Hyphomycetes*.

6. Amongst the *Hyphomycetes* such species as *Hormonema dematioides* and *Hormodendrum cladosporioides* are extremely common, inter alia upon live leaves and other parts of the plants — both almost without exception forming constituent parts of so called sooty mildew.

7. The majority of the blueing fungi are living almost exclusively in the parenchymatous tissues of the sapwood (some of them, e. g. *Endoconidiophora cœrulescens* and *Leptographium Lundbergii*, display, however, a great tendency to grow simultaneously longitudinally through the tracheids). As is well known, the discoloration designated as blueing is then practically confined to the sapwood. Our researches have, however, indicated that also quite typical blueing of the heartwood occurs (caused, for example, by *Hormodendrum microsporum)*. In the latter the hyphæ do not display any predeliction for the pith-rays and resin-ducts.

8. With regard to the details in the development of the mycelium in the wood there occurs, furthermore, so vast differences between the various species of fungi that several clearly characterised types can be set up. This, for instance, holds good for the capacity of conidial development within the wood, and the manner of the hyphæ in perforating the tracheid membranes. It is, however, as a rule impossible to draw up a perfectly safe working definition merely by the aid of the morphological forms of the mycelium. One exception to this is *Hormonema dematioides*.

9. Most of the species have been experimentally investigated as to their need of water and oxygen content in the wood, and also in respect of the dependency upon temperature for their rapidity of growth. Moreover, the action exercised in every particular case by the specific quality of the timber upon the bluieng capacity of the fungi has been inquired into.

10. With regard to the rapidity of growth of the fungi in wood with the same water content, there exists a manifest difference when they are allowed to grow in paraffined and non-paraffined sectors. This circumstance is explained by the fact that oxygen in the course of the test penetrates more slowly into the former than into the latter material. The chances of the development of the fungi in a paraffined sector correspond most closely to those presented to them in nature in round timber, and the non-paraffined sector may be placed on the same level as sawn timber.

11. The water content normally occuring in winter-felled timber does not admit any, or at all events an extremely slight blueing, on account of too small a supply of oxygen. In non-paraffined sectors from such timber a loss of water of about 10 % has, however, been sufficient for the fungi to attain their optimal development. In those sectors which had been paraffined a reduction of water of 60—80 % had, however, first to be made in order to attain this optimum. In the former case the fungi display a very broad optimal zone of growth, in the latter the optimum is strongly confined, this being due to quite a different ventilation during the course of the test. An exception in this respect is chiefly *Ceratostomella Pini*, which has grown equally well, no matter how the sectors had been treated.

12. The conclusion must be drawn from the tests that different blueing fungi have different needs of oxygen. To those requiring most oxygen belong *Discula pinicola* and *Trichosporium tingens;* to those requiring least, *Hormonema dematioides* and *Ceratostomella Pini.*

13. After the maximal blueing has been reached, the amount of water available for the hyphæ is decisive for their intensity of growth. With a water content approximating the fiber saturation point (about 30 % of the dry substance) the fungi are no longer able to discolour the timber. But for some species the lower limit is higher than for others.

14. In timber with secondarily, free water some species (e. g. *Endoconidiophora cœrulescens)* do not develop at all; others extremely feeble (e. g. *Ceratostomella cœrulea).* For the *Hyphomycetes* and the *Sphæropsidaceæ* investigated this factor is of no very great importance.

15. Agar-cultures have been used for determining the requirements of temperature by the fungi. The optimum is generally about + 22° C. The lower limit is probably located immediatedly above zero.

16. Spruce-timber is on the whole not such a favourable substratum for the blueing fungi as pine. A certain capriciousness has, however, been discovered in this respect, inasmuch as certain species have occasionally been making serious attacks; in other instances none at all.

17. Spring- and summer-felled timber is from a nutritive point of view no more favourable for the blueing fungi than winter-felled. With regard to spruce, rather the opposite appears to be the case. If summer-felled timber is more exposed to blueing than winter-felled, which has been stored so as to obviate evaporation, this is due to the water and oxygen contents having been more favourable to the fungi in the first-mentioned case.

18. During the summer the water content drops on account of

transpiration of the trees — especially in spruce — to such a degree that there is a possibility for certain fungi to penetrate into the live trunks, where the wood has been exposed. An example of this is the so called »blaze-blueing» in spruce, caused by *Endoconidiophora cœrulescens* and *Discula pinicola*.

19. The behaviour of the fungi in pine-timber of different density has been investigated. In the course of these researches it has been demonstrated that at least the majority of the species under otherwise optimal conditions develop rapidly also in timber with great density. Even if in many cases the rapidity of growth was less in narrow-ringed than in broad-ringed pine-timber, this fact has nevertheless not existed throughout. The behaviour of the fungi in spruce-timber of different density has not been investigated.

20. Different fungi behave very differently in floated timber. The more sensitive species are unable to develop in the same, while others here cause distinct blueing. Of the latter, some grow more slowly in floated than non-floated timber; others, on the contrary, equally well in both. To these belong *Hormonema dematioides* and *Cadophora fastigiata*, which also belong to the commonest blueing fungi in the timber-yards.

ADDENDUM.

After the above was written we have found that *Dematium pullulans* de Bary et Loew has already been treated critically from a systematic point of wiew. In a paper on the genera *Monilia*, *Oidium*, *Oospora* and *Torula*, CHRISTINE MARIE BERKHOUT (1923, p. 54) has also unravelled some species referred to the genus *Dematium*, amongst these *D. pullulans*. Just as we have done, the authoress has deemed it necessary to found a new genus on this type of mycelium which she calls *Pullularia*. The accompanying diagnosis being, however, only given in Dutch (work cit. p. 64) the genus *Hormonema* founded by us must according to established custom be considered valid, although it is of more recent date, because a Latin diagnosis is appended to our denomination (cf. p. 233). It is possible that the fungus named *Pullularia pullulans* by Miss BERKHOUT is identical with our *Hormonema dematioides*, although the figures given by her (work cit. fig. 32) hardly favour such an assumption.

PART II.

DAMAGE TO ROUND TIMBER WITH DIFFERENT METHODS OF STORAGE AND TREATMENT.

1. Practical purposes of storage.

The storage of timber may serve very different purposes.

Saw-logs and similar assortments one has sometimes involuntarily to leave in the forest, e. g. on account of insufficient snow, and are then stored there awaiting the next lumbering season. At the mills or factories the timber must also be stored for longer or shorter periods awaiting sawing or other methods of turning it into a merchantable article.

In these and similar cases the interest connected to storage is merely to protect the timber in the very best manner against damage during storage, without any regard as to whether drying takes place or not in this connection.

In other instances, again, the chief purpose of storage may be to dry the timber, and to effect drying with the least possible damage.

Such is the case with round-timber assortments which are to be floated and which, on account of the broad-ringed nature or slight amount of heart, can only by drying attain the necessary floatability; with pit-props and pulp-wood assortments which for pure reasons of freight must be dried before transport out of the forest, e. g. where such transport has to take place by vehicles or railway for any lengthy distances. And finally, round-timber must sometimes for technical reasons be dried before it is worked up, e. g. pulp-wood for the wood-pulp mills, this drying nevertheless chiefly being effected in the timber-yards of the mills.

We have therefore been obliged to divide our storage-tests with round-timber into two series, one of which deals with timber which, apart from drying, for a fairly short period, i. e. not more than a summer-season, has to be stored for the sole purpose of protecting it in the best way against damage, and the other deals with timber which by storage it is desired to dry with the least possible damage.

As saw-logs which have been left in the forest, and have had to be stored there during a summer-season present a typical example of the former group, we have called this series »Storage of saw-logs», and as pulp-wood frequently has to be dried before it is floated or transported down to the mill, and may therefore serve as an example of the other group, we have called this series »Storage of pulp-wood», independent of the fact that the conclusions to be drawn from these test-series are naturally not restricted to certain types of assortment.

2. Storage tests.

A. Storage of saw-logs.

1. Planning and carrying out of tests.

From old experience we know that timber which is lying immersed in water, or stored in water, is not appreciably exposed to storage-damage and that this form of storage, where available, is beyond doubt superior to all other methods.

Where water-storage cannot take place the question may nevertheless arise as to whether a drier or more moisture-conserving method of storage may be preferable. In order to ascertain this, seven different types of stacks were laid down for carrying out the tests, these types of stacks with regard to the treatment of the timber (decorticated or not), laying down of the stack (close-stacked or stacked promiscuously), covering of stack (uncovered, covered with spruce twigs or covered with litter and raw humus) or in respect of the uncovered types of stacks their location (in an open or shady position), with regard to the possibilities of drying were grouped fairly evenly between the driest imaginable form of storage on the one hand and the most moisture-conserving, next to water-storage, on the other, which for reasons already mentioned was considered as not requiring any attention.

Grouped in order from the drier to the damper forms of storage the following types were selected:

Stack No. 1 and 2: Timber entirely decorticated, put up in draughty stack in open location in a small clear-cut area; the stack without covering.

Stack No. 3 and 4: Timber entirely decorticated in close, uncovered stack in shady place, in older, mixed coniferous forest.

Stack No. 5 and 6: Timber entirely decorticated, put up in close stack in shady place. The stack covered with spruce-twigs.

Stack No. 7 and 8: Timber intact, put up in draughty, uncovered stack in an open and free position.

Stack No. 9 and 10: Timber intact, put up in close, uncovered stack in a shady place.

Stack No. 11 and 12: Timber intact (stack No. 11 for checking-in of timber by mistake decorticated at the top for a length of about 1 foot) put up in close stack direct upon levelled ground, in a shady place. Stack covered with thick layer of spruce twigs.

Stack No. 13 and 14: Timber intact (in stack No. 13 some logs were nevertheless by an oversight decorticated at the top) put up in close

stack direct upon levelled ground — stack No. 13 edge of bog — but both in shady places and covered all over with a layer of moss, litter and raw humus.

In order to ascertain how far timber felled in midwinter was equally susceptible to storage damage in comparison with that felled farther on towards the spring, and in order at the same time to get better possibilities of controlling the experiments, duplicate stacks of each one of the aforesaid types were put up, one (all stacks with odd numbers) composed of logs felled in the beginning of January, 1923, and the other (stacks with even numbers), of logs felled during the latter part of March or beginning of April in the same year.

Every stack was composed of about 100 saw-logs, about 60 % pine and 40 % spruce, mixed together in the same way as happens in an ordinary stack of timber.

The saw-logs came from about 100-year old forest on fairly good moraine soils. The volume-weight, content of heartwood of the timber etc. and other details will be seen from Table 21.

During the time from the 4th to the 10th April, approximately at the melting of the snow, the stacks were erected and covered in the manner stated. Their size and appearance can also be seen from fig. 87 and 88.

After the stacks had been put up in this manner they were allowed to remain undisturbed during the summer and right into the month of November, when winter set in and the investigation proper commenced. Superficial examination of the evident blueing attacks on stacks with wholly decorticated logs were nevertheless made in the course of the summer. On the 15th of July the first evident blueing attacks were certified and these attacks increased afterwards successively during the summer in the same way as on the bark-damaged or decorticated portions of logs in other stacks.

On breaking up and investigating the stacks, which took place in the middle of November, the logs were again weighed in order to ascertain the evaporation of water or change in weight which the timber had undergone during storage.

The change in weight thus ascertained will be seen from Table 21, where it can be seen that any appreciable evaporation only occurred in the stacks 1 to 4, i. e. those composed of wholly decorticated timber in uncovered stacks, where evaporation had varied between 24 and 33 % of the original weight. The evaporation in stacks 5—10 is, as it seems, relatively slightly varying between 1 % and 6 % of the original weight, i. e. both for wholly decorticated, spruce twig covered stacks and for non-decorticated, uncovered stacks. In the non-decorticated and covered

Table 21. **Summary of the nature of the timber in the stacks.**

Sammandrag över virkets i vältorna beskaffenhet.

No. of stack Vältans nr	No. of logs Stockarnas nr	Kind of wood Trädslag	Number Antal	Cubic bulk Kubikmassa fm³	Weight on erecting stack 4—5 April Vikt vid vältans läggning 4—5 april kg.	Weight on investigating stack 10—15 Nov. Vikt vid vältans revidering 10—15 nov. kg.	Volume-weight with bark on stacking Volymvikt med bark vid läggningen	Volume-weight without bark on stacking Volymvikt utan bark vid läggningen	Loss of weight in % of original weight (— when timber has lost; + when timber has gained in weight) Viktminskningen i % av ursprungsvikt (— då timret lättat; + då timret ökat i vikt)	Top diameter of heart in % of total top-diameter Kärnans toppdiam. i % av total toppdiam.
1	501—600	P.	54	8,480	7 273	4 837	--	0,858	-- 33,49	49,84
		Sp.	40	7,101	5 594	4 016,5		0,788	— 28,21	64,49
2	701—800	P.	60	11,537	9 403	6 424	—	0,815	— 31,68	51,30
		Sp.	38	10,327	7 550	5 606	--	0,731	— 25,75	60,47
3	101—200	P.	59	12,733	10 465	7 945	—	0,822	— 24,08	56,03
		Sp.	41	7,290	5 429	3 992	—	0,745	— 26,47	62,01
4	1,001—1,100	P.	60	11,779	9 604	6 918	—	0,815	— 27,97	56,63
		Sp.	40	9,076	6 734	5 027	—	0,742	— 25,35	55,11
5	1—100	P.	60	11,749	10 015	10 210	-	0,852	+ 1,95	54,22
		Sp.	40	7,324	5 796,5	5 703,5	--	0,792	— 1,61	65,72
6	1,101—1,200	P.	59	10,543	8 227	7 744	—	0,780	— 5,87	57,84
		Sp.	40	7,845	5 913	5 813		0,754	— 1,69	42,21
7	401—500	P.	56	9,588	7 798	7 550,5	0,813	—	— 3,17	51,77
		Sp.	43	9,354	7 217	6 832	0,772	—	— 5,33	58,36
8	801—900	P.	59	13,403	10 351	10 003	0,772	—	— 3,36	52,22
		Sp.	40	11,019	8 466	8 076	0,768	—	— 4,61	—3
9	201—300	P.	55	12,256	9 615	9 215	0,785	—	— 4,16	54,54
		Sp.	43	11,404	8 783	8 250	0,770	—	— 6,07	61,87
10	301—400	P.	61	14,316	11 085[1]	10 624	0,771	—	— 4,16[2]	53,35
		Sp.	38	8,829	6 779[1]	6 368	0,765	—	— 6,07[2]	52,58
11	901—1,000	P.	60	10,870	8 177	8 441	0,752	—	+ 3,23	57,50
		Sp.	39	8,900	6 268	6 359	0,704	—	+ 1,45	67,77
12	1,301—1,400	P.	57	11,400	8 837	9 300	0,775		+ 5,24	55,53
		Sp.	42	10,155	7 423	7 795,5	0,731	—	+ 5,02	—3
13	601—700	P.	54	12,301	9 449	10 216	0,768	—	+ 8,12	57,04
		Sp.	40	7,731	6 496	6 588	0,840		+ 1,42	63,28
14	1,201—1,300	P.	59	13,411	9 765	10 439,5	0,728	—	+ 6,91	55,73
		Sp.	40	8,517	6 320	6 654	0,742	—	+ 5,29	50,194

P. pine. Sp. = spruce.

[1] Stack not weighed on putting up, but weight calculated with the guidance of the weight of the stack on investigation and the loss in weight in % of the original weight.

[2] These figures have been taken from stack No. 9, which was laid up almost analogously with stack No. 10.

[3] Diameter of heartwood not stated.

[4] Diameter of heartwood only for 1 spruce.

Photo by T. Lagerberg.

Fig. 87. Timber entirely decorticated in a cross draught stack.
Korsdragen välta med helbarkat timmer.

Photo by T. LAGERBERG

Fig. 88. Timber entirely decorticated in closely packed stack covered with spruce twigs.
Klossvälka av helbarkat timmer, täckt med granris.

stacks 11—14, on the other hand, the timber had not dried at all but rather become heavier and increased in weight from 1—8 %. Partly this increase in weight may be ascribed to attaching moisture in the shape of ice frozen on to the bark.

Amongst other observations made on pulling down the stacks, the following may be pointed out:

In the non-decorticated stacks covered with raw humus the bark of the timber, unless specially exposed to violence, was still alive and the wood below it perfectly fresh as in a live tree. The bark on all logs was, however, entirely covered by a white network of hyphal strands and rot had commenced in the wood at almost all those spots where the bark had been removed by violence or otherwise, and also, though to no great extent, through the end surfaces of the logs.

As has been pointed out in the preceding, some of the intact timber in the litter-covered stacks had by mistake been decorticated at the upper end for check-measuring. These decorticated ends were found to be severely attacked by storage-rot (caused by *Stereum sanguinolentum*), which explains that the result of storage in these stacks at the objective inspection at the saw-mill did not give as favourable a result as one might have expected at the first ocular inspection, when the timber on the whole appeared to be sound and undamaged.

On the wholly decorticated timber put up in uncovered stacks rather large cracks had during the height of summer been noticed in the outer rows of the stack. These cracks were nevertheless at the inspection in November quite invisible, as they had closed up again.

In order to obtain a perfectly objective expression both for the extent of the damage in the timber stored in different manners, and an expression for the economic effect of this damage upon the result at the saw-mill, the timber was carted to the Garpenberg Saw Mill in November, and there sawn in February, and on that occasion carefully examined.

When sawing, all sizes of timber occurring were pieced up in the same way, i. e. in such a way that the pith was cleft and on each side of the central cut there was first removed a 2″ thick batten and outside the same 1″ deals. Before trimming the sawn timber, the frequency of the blueing and rot was ascertained not only upon the inside of the 2″ sizes but also on the outside of the first right hand side 1″ sizes. When determining the damage both storage-rot and blueing were divided into three classes or intensities. The feeblest form consisted of a faint, light-blue colour or light-brown stain through storage-rot, designated respectively with b and r, while, on the other hand, to the severest form were relegated dark-blue colouring and entirely brown-

stained storage-rot, designated respectively with ***b*** and ***r***. Between these strongly marked extreme positions was also established an intermediate position designated respectively with *b* and *r* for blueing and rot.

The determination of the damage was effected on test-lines laid right across the planks at a distance of 2 feet from each other. The damage is thus given in % of the plank-surface in the Tables 22—25.

When sawing the timber no cracks could be discovered, inasmuch as those that possibly existed had again been closed during the winter through the damp nature of the wood. The investigation of the occurrence of cracks was therefore put off until the beginning of June, when the sawn timber, which in the meantime had been stacked, properly labelled, in a timber-yard in the ordinary way, under cover, was once more carefully investigated.

For the purpose of obtaining an objective expression for the occurrence of cracks, the following method was adopted.

The cracks were examined on crosswise test-lines on every alternate fot of length on one side, and on one edge of the planks or deals. The cracks in the sides (flat surfaces) were divided into three classes, fine cracks designated with cs which were less than 1 mm. wide and did not pass right through; medium sized cracks with *cs*, over 1 mm. wide, half-open but not running right through; and big cracks ***cs***, chiefly passing right through or very wide. The cracks in the edges were summarised in one class and designated with ce.

In order to get an objective expression for the occurrence of cracks in the different sizes the number of the various kinds of cracks was placed in direct relation with 100 inches of investigated or gauged line.

By way of summary the occurrence of cracks is explained in Table 26. When the sawn timber had reached shipping-dryness through storage, or simultaneously with the investigation into the occurrence of cracks in June, the timber was sorted out according to custom into 6 classes for determining the economic effect of storage-damage.

When sorting the timber, which was done by a practiced sorter, the mill foreman at Garpenberg Saw Mill, manufacturing defects and other damage to the timber, except pure storage-damage, were left out of account, i. e. the sorting was done merely with an eye to the occurrence of blueing, staining by rot or cracks, without which the timber in reality would have to be looked upon as of the very highest class.

The result of this sorting process and the result and the distribution of the sawn timber from the respective forms of storage between quality-classes will be seen from Tables 27—30.

Table 22. **Summary of amount of damage by blueing and rot in % of surface. Middle-assortment. Pine.**

b = faint blueing, *b* = medium blueing, **b** = intense blueing.
r = faint rot, *r* = medium amount of rot, **r** = serious rot.

Sammandrag över svampskadornas omfattning i % av ytan. Mittsort. Tall.

b = svag blånad, *b* = medel blånad, **b** = stark blånad.
r = svag rötskada, *r* = medel rötskada, **r** = stark rötskada.

No. of stack Vältans nr	No. of logs Stockarnas nr.	Treatment Behandling	Method of stacking Upplägningssätt	Covering Täckning	Time of felling Avverkningstid	Amount of damage in % of surface Skadans omfattning i % av ytan								
						b	*b*	**b**	B	r	*r*	**r**	R	B+R
1	501—600	Wholly decorticated. Helbarkat.	Open place in stack with cross draught. Öppet läge i korsdragen välta.	Uncovered. Obetäckt.	January. Januari.	13,05	7,33	1,63	22,01	4,97	2,43	0,00	7,40	29,41
2	701—800	Wholly decorticated. Helbarkat.	Stack with cross-draught. Korsdragen välta.	Uncovered. Obetäckt.	March. Mars.	10,28	6,43	1,85	18,56	2,00	3,63	0,35	5,98	24,54
3	101—200	Wholly decorticated. Helbarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	January-February Januari—februari	8,46	5,32	1,56	15,34	7,23	6,26	0,53	14.02	29,36
4	1 001 1 100	Wholly decorticated. Helbarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	March—April Mars—april.	8,06	3,11	1,30	12,47	6,52	2,87	0,23	9,62	22,09
5	1—100	Wholly decorticated. Helbarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Covered with spruce twigs. Täckt med granris.	January-February Januari—februari.	2,03	0,23	0,10	2,36	3,66	1,03	0,18	4,87	7,23
6	1 101—1 200	Wholly decorticated. Helbarkat.	Shady position in closely packed stack on levelled ground.. Skuggigt läge i klosslagd välta å avplanad mark.	Covered with thick layer of spruce twigs. Täckt med granris i tjockt skikt.	March—April. Mars—april.	0,87	1,34	1,37	3,52	8,60	2,56	0,34	11,50	15,02

7	401—500	Intact. Obarkat.	Open position in stack with cross-draught. Öppet läge i korsdragen välta.	Uncovered. Obetäckt.	January Januari.	0,52	1,19	0,29	2,00	6,17	3,78	0,06	10,01	12,01
8	801—900	Intact. Obarkat.	Open position in stack with cross-draught. Öppet läge i korsdragen välta.	Uncovered. Obetäckt.	March. Mars.	1,30	0,47	0,67	2,44	3,44	1,19	0,39	5,02	7,46
9	201—300	Intact. Obarkat.	Shady position in stack with cross-draught. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	January. Januari.	1,25	0,51	0,31	2,07	5,00	3,78	0,10	8,88	10,95
10	301—400	Intact. Obarkat.	Shady position in stack with cross-draught. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	March—April. Mars—april.	0,34	0,18	0,19	0,71	6,20	2,77	0,04	9,01	9,72
11	901—1 000	Top-decorticated. Toppbarkat.	Shady position in closely packed stack direct upon levelled ground. Skuggigt läge, klosslagt direkt å avplanad mark.	Covered with thick layer of spruce twigs. Täckt med granris i tjockt skickt.	January. Januari.	0,63	0,31	0,07	1,01	1,79	0,78	0,51	3,08	4,09
12	1 301—1 400	Intact. Obarkat.	Shady position in closely packed stack on levelled ground. Skuggigt läge i kloss lagd välta å avplanad mark.	Covered with thick layer of spruce twigs. Täckt med granris i tjockt skikt.	March—April. Mars—april.	0,12	0,06	0,07	0,25	5,14	0,64	0,08	5,86	6,11
13	601—700	Intact. A few logs with tops decorticated. Obarkat. Några stockar toppbarkade.	Shady position in closely packed stack. Skuggigt läge i kloss-lagd välta.	Covered with moss, litter, raw humus Täckt med mossa, förna, torv.	December—January December—januari.	0,00	0,02	0,05	0,07	2,12	0,08	0,00	2,20	2,27
14	1 201—1 300	Intact. Obarkat.	Shady position in closely packed stack. Skuggigt läge i kloss-lagd välta.	Covered with moss, litter, raw humus Täckt med mossa, förna, torv.	March—April. Mars—april.	0,34	0,28	0,36	0,98	2,98	0,73	0,18	3,89	4,87

Table 23. **Summary of amount of damage by blueing and rot in % of surface. Side-assortment. Pine.**

b = faint blueing, *b* = medium blueing, **b** = intence blueing.
r = faint rot, *r* = medium amount of rot, **r** = serious rot.

Sammandrag över svampskadornas omfattning i % av ytan. Sidosort. Tall.

b = blånad svag, *b* = blånad medel, **b** = blånad stark.
r = rötskada svag, *r* = rötskada medel, **r** = rötskada stark.

No. of stack Vältans nr	No. of logs Stockarnas nr	Treatment Behandling	Method of stacking Upplägningssätt	Covering Täckning	Time of felling Avverkningstid	Amount of damage in % of surface Skadans omfattning i % av ytan								
						b	*b*	**b**	B	r	*r*	**r**	R	B+R
1	501—600	Wholly decorticated. Helbarkat.	Open position in stack with cross-draught. Öppet läge i korsdragen välta.	Uncovered. Obetäckt.	January. Januari.	25,99	23,55	5,85	55,39	2,82	4,84	0,00	7,66	63,05
2	701—800	Wholly decorticated. Helbarkat.	Stack with cross-draught. Korsdragen välta.	Uncovered. Obetäckt.	March. Mars.	19,36	14,18	2,65	36,19	3,44	5,84	0,17	9,45	45,64
3	101—200	Wholly decorticated. Helbarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	January—February. Januari—februari.	15,33	7,45	0,46	23,24	13,19	9,97	0,19	23,35	46,59
4	1,001—1,100	Wholly decorticated. Helbarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	March—April. Mars—april.	14,54	6,70	0,67	21,91	7,53	2,79	1,15	11,47	33,38
5	1—100	Wholly decorticated. Helbarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Covered with spruce twigs. Täckt med granris.	January—February. Januari - februari.	1,31	0,53	0,49	2,33	5,99	1,95	0,58	8,52	10,85
6	1,101—1,200	Wholly decorticated. Helbarkat.	Shady position in closely packed stack en levelled ground. Skuggigt läge i klosslagd välta å avplanad mark.	Covered with thick layer of spruce twigs. Täckt med granris i tjockt skikt.	March—april. Mars—april.	1,93	2,91	1,79	6,63	13,57	6,56	0,29	20,42	27,05

7	401—500	Intact. Obarkat.	Open position in stack with cross-draught. Öppet läge i korsdragen välta.	Uncovered. Obetäckt.	January. Januari.	0,94	1,00	0,44	2,38	10,38	4,85	0,16	15,39	17,77
8	801—900	Intact. Obarkat.	Open position in stack with cross-draught. Öppet läge i korsdragen välta.	Uncovered. Obetäckt.	March. Mars.	2,70	0,61	1,92	5,23	4,76	1,42	0,56	6,74	11,97
9	201—300	Intact. Obarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	January. Januari.	1,67	0,64	0,32	2,63	7,50	5,40	0,11	13,01	15,64
10	301—400	Intact. Obarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	March—April. Mars—april.	1,04	1,04	0,15	2,23	9,27	3,59	0,03	12,89	15,12
11	901—1,000	Top-decorticated. Toppbarkat	Shady position, in closely packed stack direct upon levelled ground. Skuggigt läge, klosslagt direkt å avplanad mark.	Covered with thick layer of spruce twigs. Täckt med granris i tjockt skikt.	January. Januari.	1,16	0,46	0,42	2,04	3,66	1,55	0,36	5,57	7,61
12	1,301—1,400	Intact. Obarkat.	Shady position in closely packed stack on levelled ground. Skuggigt läge i klosslagd välta å avplanad mark.	Covered with thick layer of spruce twigs. Täckt med granris i tjockt skikt.	March—April. Mars—april.	0,43	0,33	0,38	1,14	7,47	1,54	0.00	9,01	10,15
13	601—700	Intact. A few logs with tops decorticated. Obarkat. Några stockar toppbarkade.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Covered with moss, litter, raw humus. Täckt med mossa, förna, torv.	December—January. December—januari.	0.00	0,15	0,04	0,19	3,94	0,63	0,01	4,58	4,77
14	1,201—1,300	Intact. Obarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Covered with moss, litter, raw humus. Täckt med mossa, förna, torv.	March—April. Mars—april.	0,61	0,57	0,69	1,87	4,11	1,59	0,39	6,09	7,96

Table 24. **Summary of amount of damage by blueing and rot in % of surface. Middle-assortment. Spruce.**
b = faint blueing, *b* = medium blueing, **b** = intense blueing.
r = faint rot, *r* = medium amount of rot, **r** = serious rot.

Sammandrag över svampskadornas omfattning i % av ytan. Mittsort. Gran.
b = svag blånad, *b* = medel blånad, **b** = stark blånad.
r = svag rötskada, *r* = medel rötskada, **r** = stark rötskada.

No. of stack Vältans nr	No. of logs Stockarnas nr	Treatment Behandling	Method of stacking Uppläggningssätt	Covering Täckning	Time of felling Avverkningstid	Amount of damage in % of surface Skadans omfattning i % av ytan								
						b	*b*	**b**	B	r	*r*	**r**	R	B+R
1	501—600	Wholly decorticated. Helbarkat.	Open position in stack with cross-draught. Öppet läge i korsdragen välta.	Uncovered. Obetäckt.	January. Januari.	8,46	0,21	0,45	9,12	3,94	0,43	0,42	4,79	13,91
2	701—800	Wholly decorticated Helbarkat.	Stack with cross-draught. Korsdragen välta.	Uncovered. Obetäckt.	March. Mars.	6,69	0,25	0,00	6,94	2,12	0,69	0,02	2,83	9,77
3	101—200	Wholly decorticated. Helbarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	January—February. Januari—februari.	3,65	0,34	0,00	3,99	6,21	3,97	0,14	10,32	14,31
4	1,001—1,100	Wholly decorticated. Helbarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	March—April. Mars—april.	4,28	0,19	0,00	4,47	2,02	3,19	1,54	6,75	11,22
5	1—100	Wholly decorticated. Helbarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Covered with spruce twigs. Täckt med granris.	January—February. Januari—februari.	0,23	0,00	0,02	0,25	2,94	0,90	0,02	3,86	4,11
6	1,101—1,200	Wholly decorticated. Helbarkat.	Shady position in closely packed stack on levelled ground. Skuggigt läge i klosslagd välta å avplanad mark.	Covered with thick layer of spruce twigs. Täckt med granris i tjockt skikt.	March—April. Mars—april.	0,14	0,00	0,00	0,14	10,66	2,86	0,31	13,83	13,97

7	401—500	Intact. Obarkat.	Open position in stack with cross-draught. Öppet läge i korsdragen välta.	Uncovered. Obetäckt.	January. Januari.	0,18	0,11	0,07	0,36	6,38	4,47	0,36	11,21	11,57
8	801—900	Intact. Obarkat.	Open position in stack with cross-draught. Öppet läge i korsdragen välta.	Uncovered. Obetäckt.	March. Mars.	0,09	0,00	0,00	0,09	2,47	1,80	1,28	5,55	5,64
9	201—300	Intact. Obarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	January. Januari.	0,12	0,00	0,01	0,13	7,53	3,45	0,72	11,70	11,83
10	301—400	Intact. Obarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	March—April. Mars—april.	0,19	0,02	0,00	0,21	5,81	2,79	0,34	8,94	9,15
11	901—1,000	Top-decorticated. Toppbarkat.	Shady position, in closely packed stack direct upon levelled ground. Skuggigt läge, klosslagt direkt å avplanad mark.	Covered with thick layer of spruce twigs. Täckt med granris i tjockt skikt.	January. Januari.	0,06	0,00	0,00	0,06	3,68	2,57	1,73	7,98	8,04
12	1,301—1,400	Intact. Obarkat.	Shady position in closely packed stack on levelled ground. Skuggigt läge i klosslagd välta å avplanad mark.	Covered with thick layer of spruce twigs. Täckt med granris i tjockt skikt.	March—April. Mars- april.	0,01	0,00	0,00	0,01	6,71	3,17	0,51	10,39	10,40
13	601—700	Intact. A few logs tvith tops decorticated. Obarkat. Några stockar toppbarkade.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Covered with moss, litter, raw humus Täckt med mossa, förna, torv.	December—January. December—januari.	0,16	0,03	0,00	0,19	2,14	0,36	0,00	2,50	2,69
14	1,201—1,300	Intact. Obarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Covered with moss, litter, raw humus Täckt med mossa, förna, torv.	March—April. Mars—april.	0,13	0,00	0,00	0,13	2,93	1,71	0,34	4,98	5,11

Table 25. **Summary of amount of damage by blueing and rot in % of surface. Side-assortment. Spruce.**

b = faint blueing, *b* = medium blueing, **b** = intense blueing.
r = faint rot, *r* = medium amount of rot, **r** = serious rot.

Sammandrag över svampskadornas omfattning i % av ytan. Sidosort. Gran.

b = blånad svag, *b* = blånad medel, **b** = blånad stark.
r = rötskada svag, *r* = rötskada medel, **r** = rötskada stark.

No. of stack Vältans nr	No. of logs Stockarnas nr	Treatment Behandling	Method of storage Upplägningssätt	Covering Täckning	Time of felling Avverkningstid	Amount of damage in % of surface Skadans omfattning i % av ytan								
						b	*b*	**b**	B	r	*r*	**r**	R	B+R
1	501—600	Wholly decorticated. Helbarkat.	Open position in stack with cross-draught. Öppet läge i korsdragen välta.	Uncovered. Obetäckt.	January. Januari.	22,77	1,12	0,36	24,25	2,89	1,73	0,83	5,45	29,70
2	701—800	Wholly decorticated. Helbarkat.	Stack with cross-draught. Korsdragen välta.	Uncovered. Obetäckt.	March. Mars.	11,35	0,20	0,01	11,56	3,18	1,02	0,00	4,20	15,76
3	101—200	Wholly decorticated. Helbarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	January—February. Januari—februari.	6,79	0,46	0,00	7,25	10,55	5,70	0,31	16,56	23,81
4	1,001—1,100	Wholly decorticated. Helbarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	March—April. Mars—april.	7,73	0,44	0,00	8,17	3,89	0,99	2,17	7,05	15,22
5	1—100	Wholly decorticated. Helbarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Covered with spruce twigs. Täckt med granris.	January—February. Januari—februari.	0,90	0,10	0,00	1,00	4,54	0,00	0,02	4,56	5,56
6	1,101—1,200	Wholly decorticated. Helbarkat.	Shady position in closely packed stack en levelled ground. Skuggigt läge i klosslagd välta å avplanad mark.	Covered with thick layer of spruce twigs. Täckt med granris i tjockt skikt.	March—April. Mars—april.	0,20	0,06	0,00	0,26	11,58	5,35	0,46	17,39	17,65

7	401—500	Intact. Obarkat.	Open position in stack with cross-draught. Öppet läge i korsdragen välta.	Uncovered. Obetäckt.	January. Januari.	0,30	0,13	0,25	0,68	9,15	3,91	0,50	13,56	14,24
8	801—900	Intact. Obarkat.	Open position in stack with cross-draught. Öppet läge i korsdragen välta.	Uncovered. Obetäckt.	March. Mars.	0,52	0,00	0,00	0,52	3,31	2,39	0,89	6,59	7,11
9	201—300	Intact. Obarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	January. Mars.	0,13	0,21	0,00	0,34	8,01	5,01	0,81	13,83	14,17
10	301—400	Intact. Obarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Uncovered. Obetäckt.	March—April. Mars—april.	0,25	0,29	0,00	0,54	6,44	5,51	0,55	12,50	13,04
11	901—1,000	Top-decorticated. Toppbarkat.	Shady position, in closely packed stack direct upon levelled ground. Skuggigt läge, klosslagt direkt å avplanad mark.	Covered with thick layer of spruce twigs. Täckt med granris i tjockt skikt.	January. Januari.	0,14	0,00	0,01	0,15	2,63	3,77	1,59	7,99	8,14
12	1,301—1,400	Intact. Obarkat.	Shady position in closely packed stack on levelled ground Skuggigt läge i klosslagd välta å avplanad mark.	Covered with thick layer of spruce twigs. Täckt med granris i tjockt skikt.	March—April. Mars—april.	0,00	0,00	0,00	0,00	4,82	3,36	0,44	8,62	8,62
13	601—700	Intact. A few logs with tops decorticated. Obarkat, några stockar toppbarkade.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Covered with moss, litter, raw humus Täckt med mossa, förna, torv.	December—January. December—januari.	0,08	0,00	0,08	0,16	2,77	0,16	0,00	2,93	3,09
14	1,201—1,300	Intact. Obarkat.	Shady position in closely packed stack. Skuggigt läge i klosslagd välta.	Covered with moss, litter, raw humus Täckt med mossa, förna, torv.	March—April. Mars—april.	0,07	0,00	0,00	0,07	3,81	1,98	0,12	5,89	5,96

Table 26. **Summary of results obtained in examination of occurrence of cracks.**
Sammandrag av resultat erhållna vid revision av sprickförekomst.

Stack No. Välta nr	No. of logs Stockarnas nr	Treatment. Stacking. Covering. Time of felling. Behandling. Uppläggning. Täckning. Avv.-tid	Kind of wood Trädslag	Number of cracks to 100″ of lines examined. Antal sprickor på 100 tum undersökta linjer			
				cs	*cs*	**cs**	ce
1	501—600	wh. d., cr-d., unc., Jan.—Feb.	Pine Tall	30,1	2,1	0,1	36,9
		helb. korsd. ot. jan.—febr.	Spruce Gran	21,9	3,8	0,1	29,4
2	701—800	wh. d., cr-d., unc.. March	Pine Tall	5,4	0,4	0,0	11,4
		helb. korsd. ot., mars	Spruce Gran	8,1	0,9	0,1	13,6
3	101—200	wh. d., cl-p., unc. Jan.—Feb.	Pine Tall	2,7	0,2	0,1	3,8
		helb. klossl. ot., jan—febr.	Spruce Gran	5,6	1,1	0,0	6,9
4	1,001—1,100	wh. d., cl-p., unc. March—Apr.	Pine Tall	0,0	0,0	0,0	0,0
		helb. klossl. ot. mars—april	Spruce Gran	1,5	0,2	0,2	4,1
5	1—100	wh. d., cl-p-, spruce twig-cov., Jan.—Feb.	Pine Tall	0,0	0,0	0,0	0,0
		helb. klossl. granristäckt, jan.—febr.	Spruce Gran	0,1	0,1	0,1	0,0
6	1,101—1,200	wh. d., cl-p., spruce twig-cov., March—April	Pine Tall	0,4	0,1	0,0	0,2
		helb. klossl. granristäckt. mars—april	Spruce Gran	1,1	0,1	0,06	0,4
7	401—500	int., cr-d., unc., Jan.	Pine Tall	0,0	0,0	0,0	0,0
		ob. korsd. ot., jan.	Spruce Gran	0,0	0,0	0,0	0,0
8	801—900	int., cr-d., unc., March	Pine Tall	0,1	0,04	0,1	0,0
		ob. korsd. ot., mars	Spruce Gran	0,4	0,1	0,0	0,0
9	201—300	int., cl-p.. unc., Jan.	Pine Tall	0,1	0,04	0,0	0,0
		ob. klossl, ot., jan.	Spruce Gran	4,3	0,6	1,8	0,0
10	301—400	int., cl-p., un ., March	Pine Tall	1,7	0,8	1,7	0,0
		ob. klossl. ot.. mars	Spruce Gran	0,0	0,0	0,0	0,0
11	901—1,000	t-d, cl-p., direct on ground, spruce twig-cov., Jan.	Pine Tall	0,0	0,0	0,0	0,0
		toppbarkat klossl. direkt på marken granristäckt, jan.	Spruce Gran	0,2	0,7	0,2	0,8
12	1,301—1,400	int., cl-p., spruce twig-cov., March—April	Pine Tall	0,3	0,0	0,0	0,2
		ob. klossl. granristäckt, mars—april	Spruce Gran	0,0	0,0	0,1	0,0
13	601—700	int. (t-d.), cl-p., moss, litter, raw humus, Dec.—Jan. ...	Pine Tall	1,4	2,1	0,0	0,0
		ob- (toppbarkat) klossl. mossa, förna, torv, dec.—jan.	Spruce Gran	0,0	0,0	0,0	0,6
14	1,201—1,300	int., cl-p., moss, litter, raw humus, March—April	Pine Tall	0,0	0,0	0,0	0,0
		ob. klossl. mossa, förna, torv, mars—april	Spruce Gran	0,0	0,0	0,0	0,0

Abbreviations: int. = intact; cl-p = closely packed; cr-d = cross-draught; wh-d. = wholly decorticated; unc. = uncovered; spruce twig-cov. = covered with spruce twigs; t-d. = top decorticated; Jan. = January; Feb. = February; Dec. = December; cs = fine cracks in flat surfaces of planks or deals; *cs* = medium siged cracks in flat surfaces of planks or deals; **cs** = large or through-going ditto; ce = cracks in edges.

Förkortningar: ob. = obarkat, helb. = helbarkat, korsd. = korsdragen, klossl. = klosslagd, ot. = obetäckt, jan. = januari, febr. = februari, dec. = december, cs = fina sprickor å plankornas eller brädernas plattor, *cs* = medelgrova d:o, **cs** = grova eller genomgående d:o, ce = kantsprickor,

Table 27. **Distribution of sawn timber in condition ready for shipment.**
Sågutfallets fördelning i skeppningsfärdigt skick.

Pine: 2″ middle-assortment. Tall: 2″ mittsortiment.

Stack No. Välta nr	No. of logs Stockarnas nr	Treatment. Stacking. Covering. Time of felling. Behandling. Upplägning. Täckning. Avv.-tid	Quality Kvalitet I cub. f. kbf	II cub. f. kbf	III cub. f. kbf	IV cub. f. kbf	V cub. f. kbf	VI cub. f. kbf	Regulation ends cub. f. Justerändar kbf	Total cub. f. Summa kbf
1	501—600	wh-d., cr-d., unc., Jan.—Feb.	—	—	—	—	—	56,25	—	56,25
		helb. korsd. ot., jan.—febr.						100		100 %
2	701—800	wh-d., cr-d., unc., March ...	—	—	—	—	—	65,40	—	65,40
		helb. korsd. ot., mars						100		100 %
3	101—200	wh-d., cl-p., unc., Jan.—Feb.	—	—	—	0,83	11,45	82,85	0,72	95,85
		helb. klossl. ot., jan.—febr.				0,9	11,9	86,4	0,8	100 %
4	1,001—1,100	wh-d., cl-p., unc., March—April	—	—	—	—	13,64	56,66	—	70,30
		helb. klossl. ot., mars—april					19,4	80,6		100 %
5	1—100	wh-d., cl-p., spruce twig-cov., Jan.—Feb.	—	1,11	4,59	2,21	37,80	26,33	0,77	72,81
		helb. klossl. granristäckt, jan.-febr.		1,5	6,3	3,0	51,9	36,2	1,1	100 %
6	1,101—1,200	wh-d., cl-p., spruce twig-cov., March—April	1,38	1,33	2,41	5,85	12,86	38,51	0,72	63,06
		helb. klossl. granrist., mars—april	2,2	2,1	3,8	9,3	20,4	61,1	1,1	100 %
7	401—500	int., cr-d., unc., Jan.	—	1,71	1,07	9,04	13,91	32,22	0,76	58,71
		ob. korsd. ot., jan.		2,9	1,8	15,4	23,7	54,9	1,3	100 %
8	801—900	int., cr-d., unc., March	—	1,88	3,64	7,03	33,00	31,62	1,42	78,59
		ob. korsd. ot., mars		2,4	4,7	8,9	42,0	40,2	1,8	100 %
9	201—300	int., cl-p., unc., Jan.	—	1,22	3,38	4,36	14,45	40,54	1,60	65,55
		ob. klossl. ot., jan.		1,6	5,2	6,7	22,1	61,9	2,5	100 %
10	301—400	int., cl-p., unc., March—April	2,19	6,53	6,27	4,75	23,38	29,43	2,26	74,81
		ob. klossl. ot., mars—april	2,9	8,7	8,3	6,4	31,3	39,4	3,0	100 %
11	901—1,000	t-d., cl-p., direct upon ground spruce twig-cov., Jan.	2,58	2,93	4,74	8,65	28,47	10,14	2,87	60,38
		toppbarkat, klossl., direkt på marken, granristäckt, jan.	4,3	4,8	7,8	14,3	47,2	16,8	4,8	100 %
12	1,301—1,400	int., cl-p., spruce twig-cov., March April	11,98	8,95	10,31	8,36	14,01	4,92	2,92	61,45
		ob. klossl., granristäkt, mars—april	19,5	14,5	16,8	13,6	22,8	8,0	4,8	100 %
13	601—700	int., (t-d), cl-p., moss, litter, raw humus, Dec.—Jan. ...	2,72	7,19	6,07	26,94	20,71	4,62	2,20	70,45
		ob. (toppbarkat) klossl. mossa, förna, torv, dec.—jan.	3,9	10,2	8,6	38,2	29,4	6,6	3,1	100 %
14	1,201—1,300	int., cl-p., moss, litter, raw humus, March—April	—	2,84	7,74	11,02	27,00	19,79	2,11	70,50
		ob. klossl. mossa, förna, torv, mars—april		4,0	11,0	15,6	38,3	28,1	3,0	100 %
	Grand total for entire parcel 2″ pine deals		20,85	35,69	50,22	89,04	250,68	499,28	18,35	964,11
	S:a Summarum för hela partiet 2″ bräder tall		2,2	3,7	5,2	9,2	26,0	51,8	1,9	100 %

Abbreviations: int. = intact; cl-p. = closely packed; cr-d. = cross-draught; wh-d. — wholly decorticated; unc. = uncovered; spruce twig-cov. = covered with spruce twigs; t-d. = top decorticated; Jan. = January; Feb. = February; Dec. = December.

Förkortningar: ob. = obarkat, helb. = helbarkat, korsd. = korsdragen, klossl. = klosslagd, ot. = obetäckt, jan. = januari, febr. = februari.

Table 28. **Distribution of sawn timber in condition ready for shipment.**
Sågutfallets fördelning i skeppningsfärdigt skick.

Pine: 1″ side assortment. Tall: 1″ sidosortiment.

Stack No. Välta nr	No. of logs Stockarnas nr	Treatment. Stacking. Covering. Time of felling Behandling. Uppläggning. Täckning. Avv.-tid	Quality Kvalitet I	II	III	IV	V	VI	Regulation ends cub f. Justerändar kbf	Total cub. f. Summa kbf
			cub. f. kbf	cub. f. kbf	cub. f. kbf	cub. f. kbf	cub. f. kbf	cub. f. kbf		
1	501—600	wh-d., cr-d., unc., Jan.—Feb.	—	—	—	—	0,52	8,16	—	8,68
		helb. korsd. ot. jan.—febr.					6,0	94,0		100 %
2	701—800	wh-d., cr-d., unc., March ...	—	—	—	—	2,42	6,83	0,20	9,45
		helb. korsd. ot., mars					25,6	72,3	2,1	100 %
3	101—200	wh-d., cl-p., unc., Jan.—Feb.	—	—	—	0,42	4,72	8,20	0,37	13,71
		helb. klossl. ot., jan—febr.				3,1	34,4	59,8	2,7	100 %
4	1,001—1,100	wh-d., cl-p., unc., March—April	—	—	—	—	3,82	7,24	0,14	11,20
		helb. klossl. ot., mars—april.					34,1	64,6	1,3	100 %
5	1—100	wh-d-b., cl-p., spruce twig-cov., Jan.—Feb.	0,97	0,94	—	1,83	4,86	3,24	0,86	12,70
		helb. klossl. granristäckt, jan—febr.	7,6	7,4		14,4	38,3	25,5	6,8	100 %
6	1,101—1,200	wh-d., cl-p., spruce twig-cov., March—April.....	0,50	0,83	0,91	0,54	5,11	3,37	0,18	11,44
		helb. klossl. granrist., mars—april	4,4	7,2	7,9	4,7	44,7	29,5	1,6	100 %
7	401—500	int., cr-d., unc., Jan.	0,36	—	1,14	1,3	1,22	1,73	0,14	5,62
		ob., korsd. ot., jan.	6,5		20,2	18,3	21,8	30,7	2,5	100 %
8	801—900	int., cr-d., unc., March	2,36	1,74	1,06	0,70	2,13	2,85	0,88	11,72
		ob. korsd. ot., mars	20,1	14,9	9,0	6,0	18,2	24,3	7,5	100 %
9	201—300	int., cl-p., unc., Jan.	0,50	—	—	0,78	3,60	0,89	0,33	6,10
		ob. klossl. ot., jan.	8,2			12,8	59,0	14,6	5,4	100 %
10	301—400	int., cl-p., unc., March—April	1,25	0,33	1,08	4,26	2,80	2,84	1,78	14,34
		ob. klossl. ot , mars—april	8,7	2,3	7,6	29,7	19,5	19,8	12,4	100 %
11	901—1,000	t-d., cl.-p., direct upon ground spruce twig-cov., Jan.	1,77	—	0,50	1,45	0,69	1,05	0,68	6,14
		toppbarkat, direkt klossl. på marken granristäckt, jan.	28,8		8,2	23,6	11,2	17,1	11,1	100 %
12	1,301—1,400	int., cl-p., spruce twig-cov., March—April	0,76	0,36	2,12	1,70	1,72	2,51	0,68	9,85
		ob. klossl. granrist., mars—april	7,7	3,7	21,5	17,2	17,5	25,5	6,9	100 %
13	601—700	int. (t-d.) cl-p., moss, litter, raw humus, Dec.—Jan. ...	1,35	2,79	0,36	2,21	3,46	2,01	0,30	12,48
		ob. (toppbarkat) klossl. mossa, förna, torv, dec.—jan.	10,8	22,4	2,9	17,7	27,7	16,1	2,4	100 %
14	1,201—1,300	int., cl-p., moss, litter and raw humus, March—April	—	1,28	1,24	1,77	2,54	7,19	0,72	14,74
		ob. klossl. mossa. förna, torv, mars—april		8,7	8,4	12,0	17,2	48,8	4,9	100 %
	Grand total for entire parcel 1″ pine deals		9,82	8,27	8,41	16,69	39,61	58,11	7,26	148,17
	S:a Summarum för hela partiet 1″ bräder tall		6,6	5,6	5,7	11,3	26,7	39,2	4,9	100 %

Abbrevations: int. = intact; cl-p. = closely packed; cr-d. = cross-draught; wh-d. = wholly decorticated; unc. = uncovered; spruce twig-cov. = covered with spruce twigs; t-d. = top decorticated; Jan. = January; Feb. = February; Dec. = December.

Förkortningar: ob. = obarkat, helb. = helbarkat, korsd. = korsdragen, klossl. = klosslagd, ot. = obetäckt, jan. = januari, febr. = februari.

Table 29. **Distribution of sawn timber in condition ready for shipment.**
Sågutfallets fördelning i skeppningsfärdigt skick.

Spruce: 2″ middle-assortment. Gran: 2″ mittsortiment.

Stack No. Välta nr	No. of logs Stockarnas nr	Treatment. Stacking. Covering. Time of felling Behandling. Uppläggning. Täckning. Avv.-tid	Quality Kvalitet I cub. f. kbf	II cub. f. kbf	III cub. f. kbf	IV cub. f. kbf	V cub. f. kbf	VI cub. f. kbf	Regulation ends cub. f. Justerändar kbf.	Total cub. f. Summa kbf
1	501—600	wh-d., cr-d., unc., Jan.—Feb.	—	—	—	—	—	37,29	—	37,29
		helb. korsd. ot. jan.—febr.						100	—	100 %
2	701—800	wh-d., cr.-d., unc., March ...	—	—	—	—	2,00	53,61	—	55,61
		helb. korsd. ot. mars.					3,6	96,4	—	100 %
3	101—200	wh-d., cl-p., unc., Jan.—Feb.	—	—	1,25	—	5,36	33,63	0,44	40,68
		helb. klossl. ot. jan.—febr.			3,1		13,2	82,6	1,1	100 %
4	1,001—1,100	wh-d., cl-p., unc, March—April	—	—	—	2,00	18,05	33,55	—	53,60
		helb. klossl. mars—april.				3,7	33,7	62,6	—	100 %
5	1—100	wh-d., cl-p., spruce twig-cov., Jan.—Feb.	—	3,50	1,15	9,57	19,43	6,60	0,93	41,18
		helb. kløssl. granristäckt, jan.-febr.		8,5	2,8	23,2	47,2	16,0	2,3	100 %
6	1,101—1,200	wh-d., cl-p., spruce twig-cov., March—April.....	7,24	2,76	4,25	2,80	5,23	14,94	3,37	40,59
		helb. klossl. granrist., mars—april.	17,8	6,8	10,5	6,9	12,9	36,8	8,3	100 %
7	401—500	int., cr-d., unc., Jan.	1,39	1,75	2,60	4,81	11,28	20,06	1,16	43,05
		ob. korsd. ot. jan.	3,2	4,1	6,0	11,2	26,2	46,6	2,7	100 %
8	801—900	int., cr-d., unc., March	—	—	1,46	6,50	21,08	17,97	1,01	48,02
		ob. korsd. ot. mars.			3,1	13,5	43,9	37,4	2,1	100 %
9	201—300	int., cl-p., unc., Jan.	1,65	1,88	1,25	2,88	10,81	38,19	1,47	58,13
		ob. klossl. ot. jan.	2,8	3,2	2,2	5,0	18,6	65,7	2,5	100 %
10	301—400	int., cl-p., unc, March—April	3,13	1,00	—	6,12	11,45	19,56	1,21	42,47
		ob. klossl. ot. mars—april.	7,4	2,3		14,4	27,0	46,0	2,9	100 %
11	901—1 000	t-d., cl-p., direct upon ground spruce twig-cov., Jan.	2,99	—	4,96	4,69	19,55	12,99	1,55	46,73
		toppbarkat, klossl., direkt på marken granristäckt, jan.	6,4		10,6	10,0	41,9	27,8	3,3	100 %
12	1,301—1,400	int., cl-p., spruce twig-cov., March—April	20,76	13,27	6,72	1,68	7,24	4,82	4,15	58,64
		ob. klossl., granrist., mars—april.	35,4	22,6	11,5	2,9	12,3	8,2	7,1	100 %
13	601—700	int. (t-d) cl-p., moss, litter, raw humus, Dec.—Jan.....	22,27	9,98	6,43	5,92	—	—	0,87	45,47
		ob. (toppbarkat) klossl. mossa, förna, torv, dec.—jan.	49,0	22,0	14,1	13,0			1,9	100 %
14	1,201—1,300	int. cl-p., moss, litter, raw humus, March—April	7,86	8,26	5,21	9,68	4,83	5,93	2,95	44,72
		ob. klossl. mossa, förna, torv, mars—april.	17,6	18,5	11,6	21,6	10,8	13,3	6,6	100 %
	Grand total for entire parcel 2″ spruce deals		67,29	42,40	35,28	56,65	136,31	299,14	19,11	656,18
	S:a Summarum för hela partiet 2″ bräder gran.		10,2	6,5	5,4	8,6	20,8	45,6	2,9	100 %

Abbreviations: int. = intact; cl-p. = closely packed; cr-d. = cross-draught; wh-d. = wholly decorticated; unc. = uncovered; spruce twig-cov. = covered with spruce twigs; t-d. = top decorticated; Jan. = January; Feb. = February; Dec. = December.

Förkortningar: ob. = obarkat; helb. = helbarkat; korsd. = korsdragen; klossl. = klosslagd; ot. = obetäckt; jan. = januari; febr februari.

Table 30. **Distribution of sawn timber in condition ready for shipment.**
Sågutfallets fördelning i skeppningsfärdigt skick.

Spruce: 1″ side-assortment. Gran: 1″ sidosort.

Stack No. Välta nr	No. of logs Stockarnas nr	Treatment, Stacking, Covering, Time of felling. Behandling. Uppläggning. Täckning. Avv.-tid	Quality Kvalitet I cub. f. kbf	II cub. f. kbf	III cub. f. kbf	IV cub. f. kbf	V cub. f. kbf	VI cub. f. kbf	Regulation ends cub. f. Justerändar kbf	Total cub. f. Summa kbf
1	501—600	wb-d., cr-d., unc., Jan.—Feb.	—	—	—	0,44	0,56	6,14	0,15	7,29
		helb. korsd. ot., jan.—febr.				6,0	7,7	84,2	2,1	100 %
2	701—800	wh-d., cr-d., unc., March ...	0,45	—	—	0,69	2,43	8,36	0,53	12,46
		helb. korsd. ot., mars.	3,6			5,5	19,5	67,1	4,3	100 %
3	101—200	wh-d., cl-p., unc., Jan.—Feb.	—	—	—	—	1,25	1,85	0,22	3,32
		helb. klossl. ot., jan.—febr.					37,7	55,7	6,6	100 %
4	1,001—1,100	wh-d., cl-p., unc., March—April	3,27	—	—	1,00	0,86	4,10	0,26	9,49
		helb. klossl. ot., mars—april.	34,5			10,5	9,1	43,2	2,7	100 %
5	1—100	wh-d., cl-p., spruce twig-cov., Jan.—Feb.	0,97	—	1,00	2,26	2,01	0,34	0,50	7,08
		helb. klossl. granristäckt, jan.—febr.	13,7		14,1	31,9	28,4	4,8	7,1	100 %
6	1,101—1,200	wh-d., cl-p., spruce twig-cov., March—April.....	3,07	0,50	0,44	0,42	1,09	2,95	0,50	8,97
		helb. klossl. granrist., mars—april.	34,2	5,6	4,9	4,7	12,1	32,9	5,6	100 %
7	401—500	int., cr-d., unc., Jan.	1,07	0,25	—	0,69	1,59	3,00	0,06	6,66
		ob, korsd. ot., jan.	16,0	3,7		10,4	23,9	45,0	1,0	100 %
8	801—900	int., cr-d., unc., March	4,51	0,89	2,28	1,59	0,81	1,22	2,20	13,50
		ob. korsd. ot., mars.	33,4	6,6	16,9	11,8	6,0	9,0	16,3	100 %
9	201—300	int., cl-p., unc., Jan.	1,40	—	2,08	0,78	1,51	0,99	0,93	7,69
		ob. klossl. ot., jan.	18,2		27,0	10,2	19,6	12,9	12,1	100 %
10	301—400	int., cl-p., unc., March—April	0,34	0,89	0,46	0,58	1,99	3,20	0,77	8,23
		ob. klossl. ot., mars—april.	4,1	10,8	5,6	7,0	24,2	38,9	9,4	100 %
11	901—1 000	t-d., cl-p., direct upon ground spruce twig-cov., Jan.	1,35	0,38	0,46	1,31	0,72	1,92	0,75	6,89
		toppbarkat, klossl., direkt på marken, granristäckt, jan.	19,6	5,5	6,7	19,0	10,4	27,9	10,9	100 %
12	1,301—1,400	int., cl-p., spruce twig-cov., March—April	5,90	1,95	0,44	0,57	0,73	1,00	1,64	12,23
		ob. klossl. granristäckt, mars—april	48,2	15,9	3,6	4,7	6,0	8,2	13,4	100 %
13	601—700	int (t-d) cl-p., moss, litter, raw humus, Dec.—Jan.....	4,37	—	—	0,34	0,94	—	—	5,65
		ob. (toppbarkat) klossl. mossa, förna, torv, dec.—jan.	77,3			6,0	16,7			100 %
14	1,201—1,300	int. cl-p., moss, litter, raw humus, March—April	2,47	0,83	—	—	0,54	0,44	0,38	4,66
		ob, klossl. mossa, förna, torv, mars—april.	53,0	17,8			11,6	9,4	8,2	100 %
		Grand total for entire parcel	29,17	5,69	7,16	10,67	17,03	35,51	8,89	114,12
		Summa Summarum för hela partiet	25,6	5,0	6,3	9,4	14,9	31,0	7,8	100 %

Abbreviations: int. = intact; cl-p. = closely packed; cr-d. = cross-draught; wh-d. = wholly decorticated; unc. = uncovered; spruce twig-cov. = covered with spruce twigs; t-d. = top decorticated; Jan. = January; Feb. = February; Dec. = December.

Förkortningar: ob. = obarkat: helb. = helbarkat; korsd. = korsdragen; klossl. = klosslagd; ot. = obetäckt, jan. = januari; febr. = februari.

After consultation with The Swedish Timber Exporters' Association the relative value of the sawn timber was fixed between the different classes as follows:

Value of	I sort	= 100	%
» »	II »	= 77,5	%
» »	III »	= 65	%
» »	IV »	= 60	%
» »	V »	= 50	%
» »	VI »	= 37,5	%

The regulation ends or split-wood has for the sake of simplicity been estimated in value equal to sort VI or at 37,5 % of the value of sort I.

If these relative values are applied to the percentage of different sort-classes in Tables 27—30 an expression for the relative value of the result is obtained in comparison to the value of undamaged timber of the highest class.

The difference between the latter value and that caused by storage-damage, or the loss of value through storage, will be seen from Table 31.

It should thus be observed that this depreciation set out in the table is to be looked upon as a maximal expression of the effect which the storage-damage might have had if the timber had otherwise been of the highest quality, i. e. sort I, which in reality naturally cannot be the case.

2. Some reflections upon the results obtained.

Damage by insects affecting the quality of the sawn timber has not made itself manifested by any form of storage.

Development of cracks through storage has only occurred to any appreciable extent in the very driest forms of storage; and only when wholly decorticated logs had been used in uncovered stacks it had economically affected them to any appreciable degree.

Blueing and storage-rot are the kinds of damage which have been chiefly instrumental in reducing the value of the timber.

The frequency and qualitative extent of both these kinds of damage are proved to be manifestly greatest in the driest forms of storage, and diminish successively towards the moister forms, reaching their minimum in the non-decorticated stacks covered with litter and raw humus where they would have been practically absent if not some of the logs had had the bark damaged, or been decorticated at the top. This damage is slightest in stack No. 13 which was laid direct upon damp, boggy ground.

No distinct difference in the frequency of blueing damage to timber

Table 31. **Relative depreciation through storage damage**
Den relativa värdeminskningen genom lagringsskador.

Stack No. Välta nr	No. of logs Stockarnas nr	Treatment. Stacking. Covering. Time of felling. Behandling. Uppläggning. Täckning. Avv.-tid	Depreciation through storage in % of the value of the fresh and intact timber. Värdeminskning genom lagringen i % av det friska och oskadade virkets värde					
			Pine Tall			Spruce Gran		
			Middle assortment of 2" thickness. Mittsortiment av 2" tjocklek	Side assortment of 1" thickness. Sidsortiment av 1" tjocklek	Total depreciation. Summa värdeminskning $\frac{2\times 2''+1\times 1''}{3}$	Middle assortment of 2" thickness. Mittsortiment av 2" tjocklek	Side assortment of 1" thickness. Sidsortiment av 1" tjocklek	Total depreciation. Summa värdeminskning $\frac{2\times 2''+1\times 1''}{3}$
			%	%	%	%	%	%
1	501—600	wh-d., cr-d., unc., Jan.—Feb. helb. korsd. ot., jan.—febr.	62,5	61,8	62,3	62,5	60,2	61,7
2	701—800	wh-d., cr-d., unc., March ... helb. korsd. ot., mars.	62,5	59,3	61,4	62,1	56,6	60,3
3	101—200	wh-d., cl-p., unc., Jan.—Feb. helb. klossl., ot., mars—april.	60,8	57,5	59,7	60,0	57,8	59,3
4	1,001—1,100	wh-d., cl-p., unc., March—April ..... helb. klossl. ot., mars—april.	60,1	58,2	59,5	57,5	37,4	50,8
5	1—100	wh-d., cl-p., spruce twig-cov., Jan.—Feb. ..... helb. klossl. granristäckt, jan.-febr.	53,0	46,8	50,9	47,2	39,3	44,6
6	1,101—1,200	wh-d., cl-p., spruce twig-cov., March—April..... helb. klossl. granrist., mars—april.	54,6	48,1	52,4	42,6	35,0	40,1
7	401—500	int., cr-d., unc., Jan. ..... ob. korsd. ot., jan.	54,4	46,0	51,6	51,4	45,7	49,5
8	801—900	int., cr-d., unc., March ..... ob. korsd. ot., mars.	53,0	37,9	48,0	53,1	30,9	45,6
9	201—300	int., cl-p., unc., Jan. ..... ob. klossl. ot , jan.	56,2	47,1	53,2	55,4	39,0	49,9
10	301—400	int., cl-p., unc., March ..... ob. klossl. ot., mars.	49,6	44,9	48,0	50,3	49,9	50,2
11	901—1,000	t-d., cl-p., direct upon ground spruce twig-cov., Jan. ..... toppbarkat, klossl., direkt på marken granristäckt, jan.	46,6	36,5	42,9	48,1	40,6	45,6
12	1,301—1,400	int., cl-p., spruce twig-cov., March—April..... ob. klossl. granristäckt, mars—april.	34,0	44,2	37,3	26,0	23,2	25,1
13	601—700	int (t-d.) cl-p., moss, thatch, peat., Dec.—Jan. ..... ob. (toppbarkat) klossl. mossa, förna, torv, dec.—jan.	41,3	38,5	40,4	16,3	10,8	14,5
14	1,201—1,300	int., cl-p , moss, thatch, peat., March—April..... ob. klossl. mossa, förna, torv, mars—april.	49,6	51,9	50,4	34,7	20,8	30,1
		Grand total for entire parcel. Summa Summarum för hela partiet	52,9	48,7	51,5	47,5	38,8	44,6

Abbrevations: int. = intact; cl-p. = closely packed; cr-d. = cross-draught; wh-d. = wholly decorticated; unc. = uncovered; spruce twig-cov. = covered with spruce twigs; t-d. = top decorticated; Jan. = January; Feb. = February; Dec. = December.

Förkortningar: ob. = obarkat; helb. = helbarkat; korsd. = korsdragen; klossl. = klosslagd; ot. = obetäckt; jan. = januari; febr. = februari; dec. = december.

felled during mid-winter and in spring has been noticeable, and this confirms therefore the results obtained in the same direction as those ascertained by laboratory tests, set out in Part I, (cf. p. 616).

As the stout logs of timber are unable by ever so airy storage to reach such a degree of dryness as will prevent the development of blueing fungi, but rather through an airy form of storage reach a degree of dryness which furthers or favours the development of these fungi, it is yet in full agreement with the conclusions we have been able to draw from the laboratory tests that blueing has become most intense in the airily erected stacks, or the driest forms of storage.

The fact that even storage-rot has become more intense in the wholly decorticated timber under open and airy conditions than in the intact timber under moister conditions of storage, may, perhaps, at first sight be calculated to cause surprise. The demands of these fungi upon moisture are relatively severe and the moisture in the fresh timber in itself is no obstacle to their development.

The condition referred to gets, however, its explanation through the formation of cracks. The logs have not even with the airiest storage time to dry so completely that the minimal content of moisture for storage-rot is reached. Through the cracks occurring after a drying-period the logs are at one and the same time infected by spores far into the wood. When these cracks in damp weather are filled with water, or closed up, the spores germinate and these logs are consequently more thoroughly infected and attacked than such as, being without cracks, can only be exposed to more superficial infection.

If we compare these experiences concerning storage-rot with those which LAGERBERG's (1924, p. 231) storage-tests have given with sulphite wood and also with those we shall touch upon later on in connection with the account concerning the storage of pulp-wood, a certain contradiction may perhaps at first sight become conspicuous, inasmuch as in these cases only the drier forms of storage had been able to protect the timber against storage-rot. It should, however, in this connection be observed that LAGERBERG's tests, in the same way as our own, with the storage of pulp-wood concern smaller sizes which dry through more quickly, besides which the aforesaid storage of saw-logs only extends over one summer.

Should the saw-logs remain stored any length of time, conditions would also soon develop to the contrary or the same as has been demonstrated in LAGERBERG's storage tests with sulphite wood, extending over a fairly long period. This means that in the course of an ensuing year of storage the damply stored timber-stacks would become thoroughly

Table 32. **Storage-damage to pulp-wood, partly decorticated (stripe-wise**
Lagringsskador å randbarkad pappersmasseved förvarad

Stack No. Valta nr	No. of logs Stockarnas nr	Treatment Behandling	Kind of wood Trädslag	Number Antal	Average diameter Medeldiameter	Heart in % of bulk Kärnved i % av massan	Cubic bulk fm^3 Kubikmassa fm^3
1	1—100	Stack laid with stickers, open position, uncovered, felled *January*...	Pine Tall	60	14,63	29,76	3,2387
		Strölagd välta, öppet läge, obetäckt, avv. *januari*.	Spruce Gran	40	14,61	30,76	2,1960
2	301—400	Stack laid with stickers, open position, uncovered, felled *March*...	Pine Tall	59	15,52	20,53	3,4607
		Strölagd välta, öppet läge, obetäckt, avv. *mars*.	Spruce Gran	41	15,55	35,86	2,4975
3	201—300	Closely packed stack, uncovered, felled *January*	Pine Tall	56	13,92	19,10	2,8931
		Klosslagd välta, utan täckning, avv. *januari*.	Spruce Gran	42	14,75	24,28	2,3368
4	401—500	Closely packed stack, shady position, uncovered, felled *March*...	Pine Tall	52	13,63	28,80	—
		Klosslagd välta, skuggigt läge, obetäckt, avv. *mars*.	Spruce Gran	34	16,07	36,81	—
5	101—200	Closely packed stack, covered with spruce twigs, felled *January*	Pine Tall	60	14,87	30,27	3,3438
		Klosslagd välta, ristäckt, avv. *januari*.	Spruce Gran	40	14,78	41,23	2,1887
6	501—600	Closely packed stack, covered with spruce twigs, felled *March*...	Pine Tall	63	14,31	28,29	3,2121
		Klosslagd välta, risbetäckt, avv. *mars*.	Spruce Gran	37	15,75	28,25	2,2900

[1] By an oversight this stack was not weighed when putting it up, but it is probably on the

permeated by storage-rot, while, on the other hand, the drier forms of storage would show a less pronounced change for the worse.

We are without any further ado able to draw this conclusion from the circumstance that the stacks of a moister type of storage were entirely permeated by mycelia, which were prevented from penetrating into the wood by the live bark, whereas the portions with damaged bark on

stripped) stored in stacks of different types during the summer of 1923.
i vältor av olika typ under sommaren 1923.

Weight in kg. Vikt i kg		Loss of weight in % of original weight. Viktminskning i % av ursprungliga	Volume weight when stacking up. Volymvikt vid läggningen dm	Storage damage in % of cross-sections (2 × damage on the end-slab + damage on the middle-slab). Lagringsskador i % av tvärsnitten (2 × skadan å ändsnittet + skadan å mittsnittet)								
on stacking on the $^{15}/_{3}$-$^{4}/_{4}$ vid avläggning den	on investigation on the $^{15}/_{11}$ vid revision den			b	*b*	**b**	Total Summa B	r	*r*	**r**	Total Summa R	Total Summa B + R
2,859,9	1,979,9	30,8	0,883	1,48	10,67	6,87	19,02	17,44	5,10	4,86	27,40	46,42
1,724,9	1,335,8	22,6	0,785	—	—	—	—	—	—	—	—	—
3,049,0	2,123,6	30,3	0,881	0,11	6,76	4,27	11,14	27,78	5,55	3,07	36,40	47,54
2,156,0	1,547,4	28,2	0,863	—	—	—	—	4,37	0,63	3,77	8,77	8,77
2,582,7	1,997,3	22,7	0,894	—	8,68	3,52	12,20	5,88	54,54	4,91	65,33	77,53
2,130,5	1,698,8	20,3	0,914	—	—	—	—	7,85	25,43	26,93	60,21	60,21
[1]	—	—	—	5,23	8,77	1,99	15,99	18,41	7,70	2,73	28,84	44,83
[1]	—	—	—	—	0,05	—	0,05	4,62	9,33	3,57	17,52	17,57
3,085,0	2,854,6	7,5	0,923	1,02	2,24	3,74	7,00	12,59	33,18	2,00	47,77	54,77
1,970,0	1,853,0	5,9	0,90	—	0,29	—	0,29	9,45	17,12	4,3	30,87	31,16
2,793,0	2,667,5	4,5	0,87	6,13	5,35	4,43	15,91	26,86	6,23	8,49	41,58	57,49
1,860,0	1,807,5	3,5	0,81	—	—	—	—	3,58	26,06	20,66	50,30	50,30

whole of the same nature as the other stacks.

logs in such stacks had been seriously attacked already during the first year of storage.

The average diameter of the aforesaid saw-logs was probably in the neighbourhood of 22 cm. In order to study not only the effect of storage-damage by partly decortication (stripe-wise stripping) but also the effect upon smaller sizes, which dry more easily through airier stacking,

a number of stacks of stripe-wise stripped pulp-wood were erected as a parallel to the aforesaid stacks of sawing-timber, the length of the former being 3 m. and their average diameter in the middle about 14,5 cm. (see Table 32). The stacks were composed of 100 logs each, 60 % being pine and 40 % spruce, mixed together in the same stack. Three different types of stack were used, viz. stack laid with stickers, uncovered in an open position; closely stacked, uncovered in a rather shady position; and closely stacked, spruce twig-covered in a shady position. Two stacks (cf. Table 32) of each type were put up, one of them composed of timber felled during mid-winter, and the other of timber felled at the end of March. The stacks were arranged during the latter part of March and the beginning of April, and were then allowed to remain undisturbed until the 15th November, when they were investigated.

At this investigation all the logs were again weighed to ascertain the changes in weight, besides which every tenth log was taken out for closer analysis of the damage due to storage. This damage was determined in such a way that from each log one slab was removed from the middle of the trunk and one about a foot from the thicker end of the log. Upon these slabs the extent of the damage was determined by planimetry, the damage in the same manner as concerning the saw-logs being divided into three values of blueing and three of storage-rot, designated respectively with b, *b*, ***b*** and r, *r*, ***r***, and their totals with B och R respectively (see Table 32). The average extent of damage in the entire log is calculated in such a way that the slab taken one foot from the thick end has been allowed to weigh twice as much as the centre-slab.

The result of the examination will be seen from Table 32. We see there that the difference in evaporation between the uncovered stacks laid with stickers, which had lost from 23—31 % of their original weight, is considerable in comparison with the spruce twig-covered, closely stacked ones, which had only lost 3,5—7,5 % of their original weight. The closely packed, uncovered stacks have, probably due to the short length of the wood — 3 m. — dried comparatively well, or 20—23 % loss of wegiht, although naturally less than the loosely packed ones.

If we further study the extent of the damage we find that the spruce in the airy, loosely packed stacks (laid with stickers) is practically almost free from damage, both as regards blueing and storage-rot (of which nevertheless in one stack there is 8,77 % of damage, but chiefly of a milder nature) and also that the spruce in almost all forms of storage has remained free from blueing. In the two moister forms of storage both closely packed, uncovered and closely packed, spruce twig-covered

stacks, on the other hand, storage-rot has made severe attacks upon the spruce (18—60 % of the bulk of the wood).

The pine-timber was also in these stacks found much more subject to both blueing and storage-rot, and that which in this instance is most calculated to cause surprise is the circumstance that the pine-timber even in the airiest form of storage (loosely packed, uncovered stack)

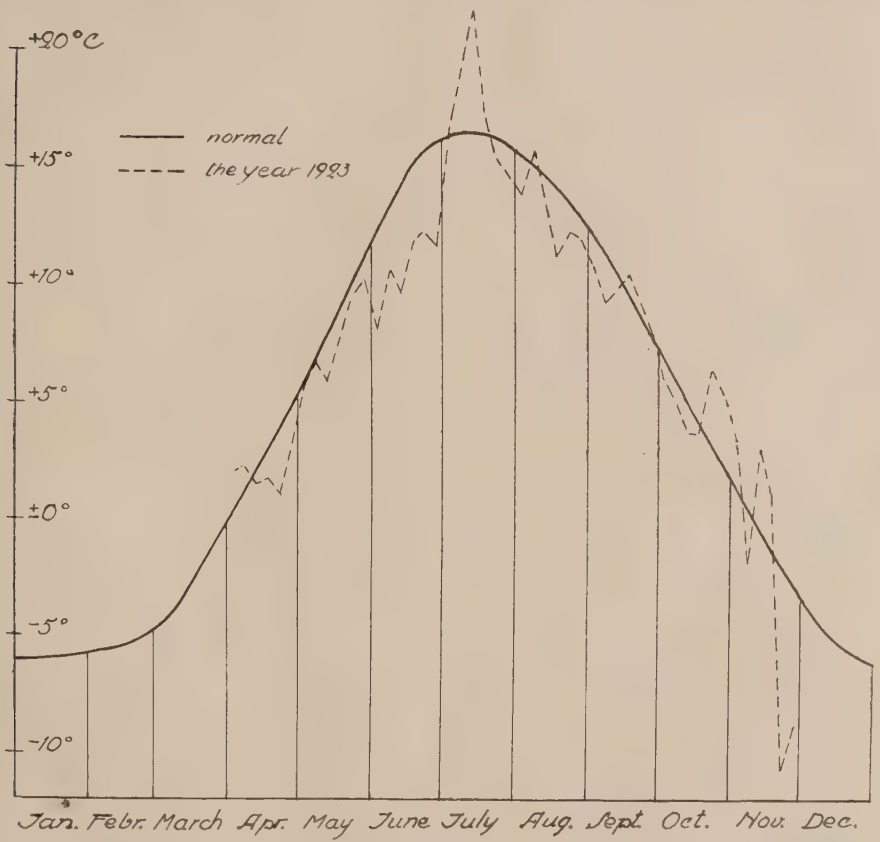


Fig. 89. Mean temperature of day for Falun.
Dygnets medeltemperatur vid Falun.

is seriously attacked by storage-rot (46 or 47 % respectively of the bulk of the wood). The moister forms of storage leave, however, also for the pine a greater percentage of damage by storage-rot, while, on the other hand, blueing appears to be approximately equal in all forms of storage, minimum 7 % and maximum 19 % of the entire bulk of the logs. The result of this series of tests may therefore be said to point absolutely in the same direction as LAGERBERG's in 1924.

The weather during the test-year was not quite normal for the district

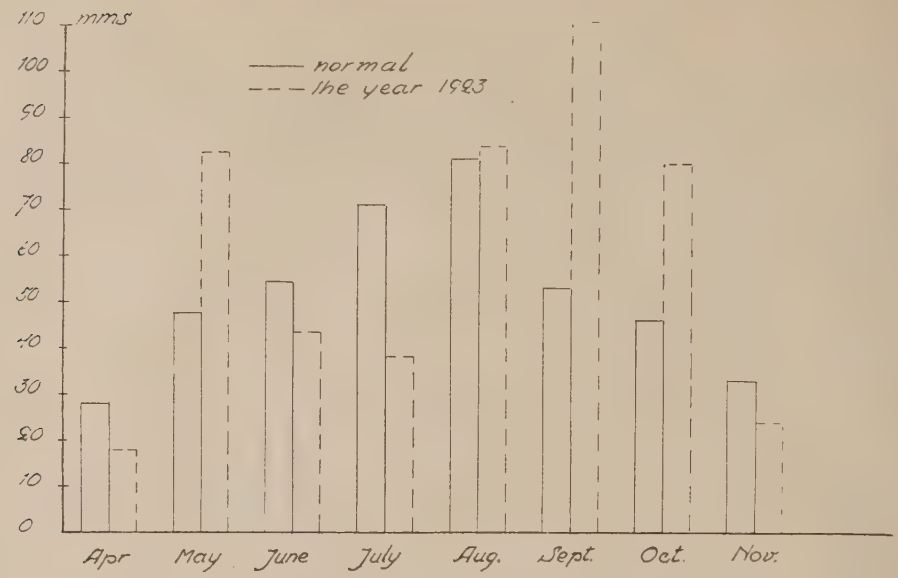


Fig. 90. Precipitation in mm. for Falun in different months.
Nederbörd i mm vid Falun under olika månader.

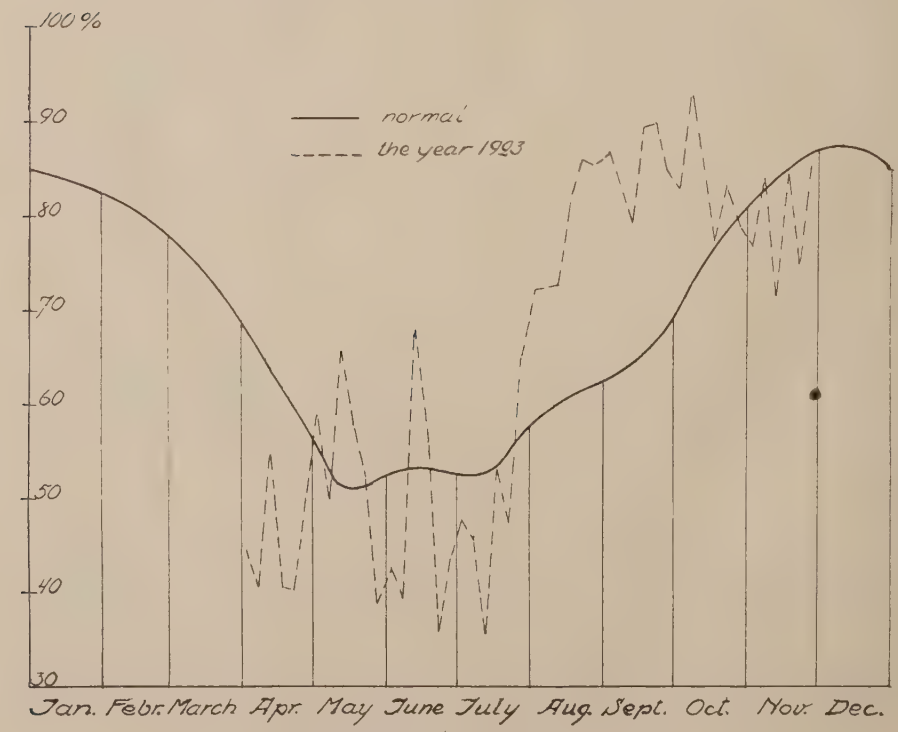


Fig. 91. Relative moisture for Falun at 14 o'clock.
Relativ fuktighet i Falun kl. 14.

in which the tests were carried out, inasmuch as the same, especially during the first part of the summer, was somewhat colder and rainier than normally. From fig. 89, 90 and 91 will be seen the temperature, average precipitation and relative average moisture, expressed in % of the full degree of saturation for Falun (the nearest metereological

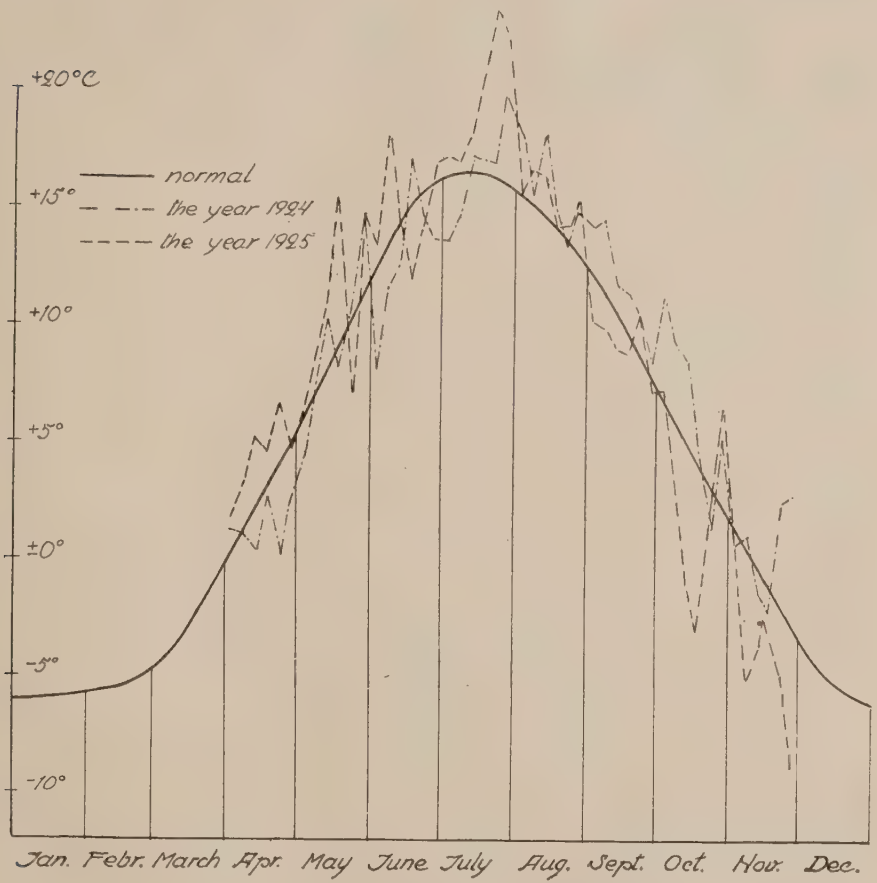


Fig. 92. Mean temperature of day for Falun.
Dygnets medeltemperatur vid Falun.

station) as well as for 1923; and on fig. 92 and 93 the conditions of temperature and precipitation for the years 1924 and 1925.

By reason of the somewhat abnormal nature of the weather conditions during 1923, and also with the idea of gaining further confirmation of the accuracy of the results obtained in that year, especially, by storing timber in stacks, covered with litter and raw humus the tests were repeated in 1924, these tests being carried out by Mr ENANDER,

at Garpenberg, along the same lines as in 1923, but with the addition of chloride of sodium being strewn in certain stacks, covered with litter and raw humus, between the layers of timber in order to reduce the possibilities of mycelia of wood destroying fungi developing in the stacks.

The result of these tests of Mr. ENANDER during 1924 turned out perfectly analogous to that obtained in 1923, though the damage in the stacks covered with litter and raw humus in which no chloride of sodium had been used was found to be more extensive than in 1923, which may find its immediate explanation in the fact that the stacks in 1924 were only

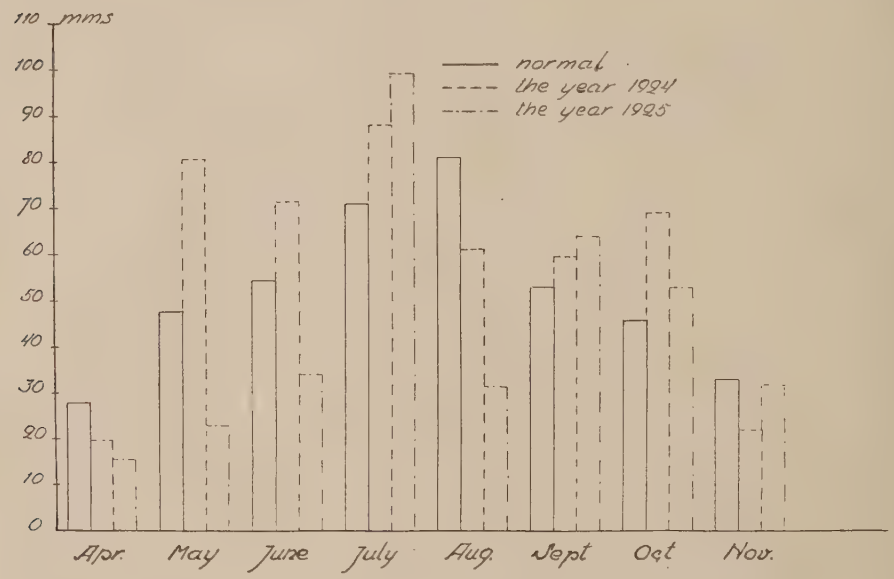


Fig. 93. Precipitation in mm. for Falun during different months.
Nederbörd i mm vid Falun under olika månader.

half the size as those in 1923. For it was found both in 1923 and in 1924 that in the stacks in question the damage was greatest in the upper portions of the stacks, while the lower layers were least attacked.

With regard to strewing chloride of sodium the result of this measure proved rather insignificant, and of manifest beneficial effect only in so far as the pine-timber is concerned. Chloride of sodium itself may possibly be too weak and far too easily washed-out a poison to protect the stacks against the development of mycelia of wood destroying fungi.

It will probably be much more effective to coat the decorticated surfaces on the timber in the stacks covered with litter and raw humus directly with some impregnation-agent of a more efficient nature.

3. Summary of the practical results of storing saw-logs.

By reason of the test-results set out herebefore, the following advice may be given as a summary concerning the most suitable treatment of saw-logs which there is no possibility of storing in water, and which must be protected in the best possible manner against storage-damage during only one summer, without drying itself being particularly aimed at:

1. If the logs are not already decorticated the bark should under all circumstances be retained, as the same during the first summer's storage is a great protection against both blueing and wood destroying fungi.

2. The intact saw-logs should be put up in as large stacks as possible, these being closely packed directly upon the levelled damp ground, preferably in a shady position.

If the bark is whole on the timber, i. e. if not even the tops have been decorticated or the bark has not been appreciably damaged on carting together the timber, the wood is still better preserved if the stacks are also covered with spruce twigs, raw humus and litter.

With regard to the erection of stacks covered with raw humus and litter, special attention must be paid to the following particulars: It is very important that the stacks are as big as possible; that they are erected in cold, shady, and not in warm places; that they are brought together as early as possible in spring, preferably whilst snow and frost still prevail, so that frost is retained in the stack as much as ever possible. The strewing of chloride of sodium probably reduces the risk of rot on decorticated wood to some extent, but is no very efficient protection, for which reason the best way for protecting such decorticated portions no doubt is to coat the same with some efficient impregnation-agent.

3. If, on the other hand, the logs are decorticated at the top or have the bark considerably damaged in bringing them together, the timber-stacks should not be covered with raw humus, litter, or a denser cover except when the exposed surfaces of the wood have been impregnated with some efficient agent. The stacks should instead be covered with a thin layer of spruce twigs.

4. If the logs are already entirely decorticated, they can be best protected by putting them up in closely packed stacks, as large as possible, in a shady place, besides which a covering of spruce twigs can be recommended.

5. If the logs are of very small sizes, less than ordinary saw-logs, or with a diameter of about 15 cm. or less, and if the same are already decorticated, an airy form of storage, in loosely packed small stacks, in an open place may nevertheless result in the least amount of damage,

and this holds good especially for spruce which under such conditions of storage is fairly efficiently protected.

It may finally be remarked that pine under all forms of storage is much more liable to storage-damage than spruce, for which reason the storage of pine-timber until another year should in the first instance be avoided wherever possible.

The time of felling, i. e. if felling takes place in mid-winter or in the latter part of winter, appears, however, not to exercise any influence upon the occurrence of storage-damage.

It need hardly be pointed out that, on the other hand, it is of the utmost importance that saw-logs, which, according to the principles advanced herebefore, have been kept over in storage for one summer, are carted during the ensuing winter and cut up as quickly as possible.

Prolonged storage of saw-logs during any part of the ensuing summer will entail a considerable increase in the storage-damage, and storage-rot will undoubtedly then become catastrophic, especially in the damp forms of storage.

B. Storage of pulp-wood.

The purpose of this series of experiments was, as has been pointed out in the preceding, to ascertain the best and most suitable method of storage in the forest, of such round-timber, which it is desirable to get dry before transporting to the mill, and to have this drying accomplished with the least possible damage to the timber.

It is obvious that here the time of felling just as much as the treatment and storage of the timber, exercise their influence.

For this reason these storage-tests were arranged — likewise at Garpenberg in 1923 — according to the following plan:

The timber intended for the storage-tests was selected in a normally close and thriving, mixed coniferous forest, about 50 years old, upon moraine soil.

The logs were cut into equal lengths, 3 m., and their diameter varied between 10 and 18 (20) cm., ordinary sizes used for pulp-wood.

Felling, treatment of the timber, and its storage in different ways took place simultaneously. The trees of the first test-series were felled on the 10th April, the second on the 15th April, and after that on the 1st and 15th in each month right up to the 1st October, when the last series was arranged.

On every occasion of felling 60 logs were cut up, half being pine and the other half spruce. Twenty of the logs were wholly decorticated, twenty stripe-wise stripped, and twenty were left intact. Of every

Table 33. **Pulp-woods loss of weight — drying — by different time of felling.**
Massaveds viktförlust — torkning — vid skilda fällningstider.

Method of treatment and stacking Behandlings- och uppläggningssätt	Kind of wood Trädslag	Time of felling (marked with ×) and loss of weight in % of original weight Avverkningstid (markerad med ×) samt viktminskning i % av ursprungsvikt													Water content in % of dry substance weight on the 16/11 Vattenhalt i % av torrsubs. vikt den 16/11	
		10/4	16/4	1/5	15/5	1/6	15/6	1/7	15/7	1/8	15/8	1/9	15/9	1/10	16/11	Root-section rotsekt.	Middle-section mittsekt.
Wholly decorticated, in triangle Helbarkat, i triangel	Pine Tall	×	5,07	14,49	20,29	31,16	34,06	38,04	38,99	35,62	36,49	34,86	33,16	33,01	31,38	35,3	
			×	12,50	14,17	33,75	33,75	39,17	45,17	38,75	39,79	36,24	36,39	36,95	33,42	34,5	33,9
					9,25	27,74	44,86	43,49	45,27	43,90	43,53	43,25	42,00	40,35	38,77	31,9	32,7
					×	25,90	31,33	38,25	40,30	40,48	38,75	39,19	37,06	37,64	33,92	35,1	34,9
						×	15,85	35,79	39,62	37,27	37,95	34,92	36,64	36,49	33,80	32,2	32,0
							×	42,51	47,86	46,55	43,07	43,00	44,15	43,41	43,69	38,5	36,6
								×	26,86	33,27	36,38	36,26	35,06	35,36	32,39	36,0	36,2
									×	17,97	17,66	22,35	25,89	26,80	25,84	76,2	79,2
										×	6,43	7,81	16,53	16,55	13,97	63,2	85,4
											×	11,14	18,54	24,52	19,13	52,1	110,1
												×	8,43	14,76	13,50	60,7	85,0
													×	6,75	6,07	139,3	144,3
														×	0,51	114,4	111,3
	Spruce Gran	×	4,30	14,45	18,75	25,78	27,73	30,47	33,28	28,13	29,06	27,54	26,52	26,48	23,52	34,9	34,2
			×	12,82	17,22	32,60	31,50	37,73	43,08	36,59	35,64	34,91	33,53	34,92	31,87	31,7	31,4
				×	8,17	26,14	39,87	36,93	38,24	35,39	35,59	35,36	34,14	31,92	30,52	31,4	33,5
					×	22,14	26,34	29,77	31,83	31,60	28,98	29,62	28,52	28,93	25,92	32,1	32,1
						×	22,01	37,31	42,61	40,04	40,30	38,36	39,25	37,57	37,05	32,6	32,3
							×	34,44	44,04	41,06	39,21	39,24	40,15	39,92	39,40	32,0	32,1
								×	27,89	30,32	32,59	33,93	27,29	28,18	25,59	31,4	31,8
									×	22,32	21,42	26,90	31,07	30,98	29,58	34,3	33,3
										×	− 2,33	− 1,71	8,18	8,90	7,47	48,8	51,3
											×	9,46	16,12	21,14	18,49	53,8	62,2
												×	10,29	14,72	15,89	77,9	62,2
													×	6,85	8,32	89,4	78,8
														×	1,72	103,8	112,3

Table 34. **Pulp-woods loss of weight — drying — by different time of felling.**
Massaveds viktförlust — torkning — vid skilda fällningstider.

Method of treatment and stacking Behandlings- och upplägg-ningssätt	Kind of wood Träd-slag	Time of felling (marked with ×) and loss of weight in % of original weight Avverkningstid (markerad med ×) samt viktminskning i % av ursprungsvikt													Water content in % of dry substance weight on the 16/11 Vattenhalt i % av torr-subs. vikt den 16/11	
		10/4	16/4	1/5	15/5	1/6	15/6	1/7	15/7	1/8	15/8	1/9	15/9	1/10	16/11	Root-section rotsekt.	Middle-section mittsekt.
Wholly decorticated, stored direct upon the ground Helbarkat, direkt å marken lagrat	Pine Tall	×	2,53	6,57	6,06	12,63	16,67	21,72	32,77	35,21	35,78	34,62	32,69	33,69	26,10	36,2	45,1
			×	5,15	7,35	13,97	17,28	28,68	35,44	35,88	35,63	32,76	34,86	34,75	28,24	37,0	40,4
				×	— 2,27	8,33	25,00	22,73	34,55	33,11	33,64	32,99	33,42	31,88	24,47	39,5	45,1
					×	8,82	8,23	13,53	25,88	33,50	33,21	32,97	34,29	34,09	28,25	68,3	91,7
						×	3,61	16,87	26,51	31,17	32,68	32,89	34,11	33,28	27,71	54,3	41,2
							×	26,22	42,80	44,27	45,34	44,36	46,23	46,59	45,46	36,3	45,3
								×	12,16	14,96	17,01	15,61	17,12	18,39	10,36	53,3	53,1
									×	5,68	6,01	3,89	7,83	7,68	1,44	86,2	108,0
										×	— 3,53	— 5,45	— 4,21	— 4,02	— 7,63	132,0	140,7
											×	— 2,57	— 3,23	— 2,67	— 9,52	135,5	129,5
												×	1,57	3,23	— 3,78	140,2	144,0
													×	1,02	— 4,18	128,8	136,1
														×	— 9,85	161,3	162,5
	Spruce Gran	×	1,62	3,57	2,60	9,09	17,53	21,10	25,00	29,03	30,36	28,52	28,27	28,07	25,78	41,8	53,2
			×	1,18	4,31	21,57	21,96	29,80	35,76	33,45	34,12	28,89	33,26	34,15	29,57	34,2	38,4
				×	— 2,10	4,90	22,38	13,63	30,07	31,12	31,57	30,91	33,52	33,03	29,27	45,0	53,8
					×	7,30	8,39	17,88	31,31	31,13	30,00	29,53	30,64	31,57	26,57	38,7	39,5
						×	3,03	21,65	28,05	30,22	30,52	29,61	31,77	31,54	20,64	43,1	38,7
							×	26,35	35,75	38,50	37,57	36,68	38,86	39,08	33,17	32,8	32,8
								×	10,27	13,89	17,26	14,97	17,80	19,28	16,01	69,2	67,9
									×	1,81	0,43	— 1,81	6,72	7,51	3,69	92,9	108,8
										×	— 0,41	— 2,52	— 8,34	— 9,52	— 15,06	108,3	120,3
											×	— 1,73	— 2,11	— 1,13	— 6,99	143,7	138,2
												×	1,96	4,43	1,41	86,4	28,4
													×	— 1,93	— 6,47	125,7	135,5
														×	— 7,81	126,6	122,8

Table 35. **Pulp-woods loss of weight — drying — by different time of felling.**
Massaveds viktförlust — torkning — vid skilda fällningstider.

Method of treatment and stacking Behandlings- och upplägg-ningssätt	Kind of wood Träd-slag	Time of felling (marked with ×) and loss of weight in % of original weight Avverkningstid (markerad med ×) samt viktminskning i % av ursprungsvikt													Water content in % of dry substance weight on the 16/11 Vattenhalt i % av torr-subs. vikt den 16/11	
		10/4	16/4	1/5	15/5	1/6	15/6	1/7	15/7	1/8	15/8	1/9	15/9	1/10	16/11	Root-section rotsekt.	Middle-section mittsekt.
Stripe-wise stripped, in triangle Randbarkat. i triangel	Pine Tall	×	2,01	4,21	5,49	9,52	8,61	15,75	21,03	23,30	24,45	22,12	24,45	25,85	22,65	40,8	80,8
			×	4,78	4,35	12,61	15,65	21,30	26,52	29,70	27,59	27,65	33,08	33,34	31,00	36,4	45,9
				×	3,61	11,34	13,14	21,65	27,06	30,29	29,43	29,72	33,01	34,12	30,77	40,6	51,4
					×	8,14	12,22	19,00	26,61	28,63	28,01	28,57	30,57	31,12	30,48	36,7	38,5
						×	4,50	13,23	21,22	23,07	23,39	23,65	25,52	25,14	23,42	71,1	82,2
							×	15,54	21,81	25,26	24,48	23,73	27,77	30,08	25,80	49,6	55,2
								×	13,46	16,29	17,00	16,75	17,74	18,80	15,57	67,6	65,1
									×	0,39	4,35	5,46	8,36	9,32	8,30	60,5	109,0
										×	2,28	2,49	3,19	6,01	0,00	111,3	138,0
											×	1,77	6,73	7,08	6,33	58,2	87,1
												×	2,40	3,73	1,25	93,9	112,2
													×	1,35	— 2,83	147,5	134,2
														×	— 4,30	114,3	118,1
	Spruce Gran	×	4,07	6,33	6,67	14,00	14,33	24,00	29,20	29,57	31,50	29,47	31,18	28,17	26,14	42,1	41,8
			×	5,21	5,21	15,38	17,12	24,07	29,38	29,61	29,21	29,33	31,33	31,92	29,28	45,3	
				×	1,41	14,08	17,96	28,17	34,86	34,49	35,49	35,67	38,20	39,14	35,27	41,8	47,7
					×	10,69	13,21	13,52	28,81	30,64	30,91	31,26	30,91	31,82	30,09	39,5	50,9
						×	6,06	17,27	28,00	29,41	29,76	29,94	31,18	30,07	28,91	41,7	43,7
							×	19,05	27,56	32,52	32,35	28,54	33,53	33,97	30,16	43,2	50,4
								×	12,11	20,99	22,48	22,30	21,64	22,77	20,24	45,0	59,0
									×	10,52	10,42	12,50	16,42	17,70	17,57	48,6	57,4
										×	2,76	3,18	6,17	8,27	3,10	106,8	140,2
											×	0,85	4,83	5,04	3,30	95,7	130,2
												×	0,83	0,97	0,64	99,0	109,4
													×	2,83	— 0,46	64,7	58,8
														×	— 3,30	119,1	115,5

Table 36. **Pulp-woods loss of weight — drying — by different time of felling.**
Massaveds viktförlust — torkning — vid skilda fällningstider.

Method of treatment and stacking Behandlings- och upplägg-ningssätt	Kind of wood Träd-slag	Time of felling (marked with ×) and loss of weight in % of original weight Avverkningstid (markerad med ×) samt viktminskning i % av ursprungsvikt													Water content in % of dry substance weight on the 16/11 Vattenhalt i % av torr-subs. vikt den 16/11	
		10/4	16/4	1/5	15/5	1/6	15/6	1/7	15/7	1/8	15/8	1/9	15/9	1/10	16/11	Root-section rotsekt.	Middle-section mittsekt.
Stripe-wise stripped, stored direct upon the ground Randbarkat, direkt å marken lagrat	Pine Tall	×	1,23	3,45	2,96	6,40	8,62	14,29	15,17	17,64	18,30	16,85	18,60	17,80	12,36	95,8	35,6
			×	2,79	1,66	6,15	8,94	10,89	18,60	20,22	18,85	19,53	19,73	20,79	15,25	65,6	93,4
				×	1,75	2,10	10,84	10,49	16,64	18,08	18,20	17,76	18,67	17,21	10,91	50,7	109,2
					×	1,72	1,72	5,82	10,17	7,42	10,88	10,65	10,48	9,84	4,09	90,7	82,4
						×	— 3,22	4,97	10,76	14,28	12,15	11,93	12,55	12,26	6,02	92,0	99,8
							×	8,66	14,94	14,21	18,79	18,04	15,22	14,11	8,20	84,5	103,7
								×	9,54	10,47	10,97	10,12	9,60	9,68	3,73	81,6	93,7
									×	2,47	2,95	2,08	1,88	2,13	— 3,41	182,3	193,5
										×	— 0,45	— 0,69	— 1,08	— 1,18	— 5,79	188,0	193,4
											×	— 1,65	0,84	— 0,13	— 3,41	148,3	153,0
												×	— 1,83	3,94	1,43	109,2	112,0
													×	— 1,43	— 6,26	112,2	140,6
														×	—9,66	138,7	146,5
	Spruce Gran	×	1,84	6,13	4,91	7,98	10,74	17,18	18,96	21,96	23,39	21,56	22,69	21,60	18,53	42,8	58,1
			×	2,35	1,49	5,76	4,48	12,37	18,29	21,32	19,89	19,81	20,14	20,00	17,36	70,3	106,7
				×	0,32	3,85	9,29	14,10	19,29	21,45	21,67	21,22	22,25	21,86	19,29	58,1	63,8
					×	17,19	17,42	23,30	31,27	31,92	31,63	31,24	31,62	31,72	28,33	43,0	63,6
						×	— 0,91	9,70	14,61	16,52	15,85	15,39	15,95	16,15	11,43	78,9	98,4
							×	10,58	16,88	18,34	23,18	22,02	19,15	18,68	14,90	100,8	76,3
								×	11,19	13,94	11,27	10,89	10,42	10,35	5,17	52,6	57,3
									×	2,38	3,31	— 0,28	1,87	0,94	— 4,43	117,2	141,8
										×	— 2,37	— 1,42	— 2,46	— 3,16	— 6,69	133,3	146,8
											×	0,43	1,97	0,72	— 0,90	92,4	105,0
												×	— 0,62	— 1,47	— 5,26	112,7	112,3
													×	— 2,42	— 7,71	103,0	113,0
														×	— 8,61	149,2	155,3

Table 37. **Pulp-woods loss of weight — drying — by different time of felling.**
Massaveds viktförlust — torkning — vid skilda fällningstider.

Method of treatment and stacking Behandlings- och upplägg-ningssätt	Kind of wood Träd-slag	Time of felling (marked with ×) and loss of weight in % of original weight Avverkningstid (markerad med ×) samt viktsminskning i % av ursprungsvikt													Water content in % of dry substance weight on the 16/11 Vattenhalt i % av torr-subs. vikt den 16/11	
		10/4	16/4	1/5	15/5	1/6	15/6	1/7	15/7	1/8	15/8	1/9	15/9	1/10	16/11	Root-section rotsekt.	Middle-section mittsekt.
Intact, in triangle Obarkat, i triangel	Pine Tall	×	2,40	1,92	2,88	2,88	3,61	5,53	10,53	9,38	10,24	11,44	13,20	13,98	8,61	49,7	139,2
			×	0,48	1,21	2,18	7,51	5,81	14,00	9,74	22,65	10,97	11,56	11,41	5,13	66,2	109,1
				×	1,99	0,40	1,59	1,59	5,82	7,06	5,34	5,64	6,80	6,57	0,76	112,3	141,9
					×	3,67	2,98	8,26	10,60	8,72	10,62	11,01	11,54	12,27	7,09	74,7	134,6
						×	2,32	4,38	7,27	7,19	7,84	8,02	9,58	9,49	4,59	76,3	98,0
							×	6,46	10,10	8,80	9,67	8,66	9,74	10,81	5,10	93,7	138,3
								×	2,88	4,12	4,70	2,51	2,48	2,68	0,80		76,1
									×	0,00	2,14	5,99	2,21	1,58	6,42	104,7	106,0
										×	0,18	0,66	1,25	2,20	3,21	124,3	168,8
											×	0,72	0,38	0,01	2,41	91,4	138,2
												×	0,30	0,12	3,37	155,4	159,4
													×	0,05	3,43	173,5	180,2
														×	3,96	93,7	108,3
	Spruce Gran	×	3,48	1,07	1,07	3,21	4,81	7,22	11,18	10,75	11,74	13,45	12,03	12,03	9,57	67,7	79,7
			×	0,36	0,00	2,86	9,20	6,43	17,14	11,78	11,46	11,86	11,65	11,42	7,43	58,8	69,3
				×	2,17	0,82	2,90	4,89	10,16	11,77	6,58	12,12	12,65	12,11	8,02	85,8	113,2
					×	3,87	2,90	10,32	15,03	13,88	14,77	15,00	16,46	16,97	13,35	52,7	93,6
						×	2,48	6,21	10,68	12,53	13,48	13,51	15,48	14,84	10,81	71,4	85,7
							×	4,64	12,13	10,36	11,07	10,33	11,36	11,81	8,66	54,5	81,0
								×	3,99	6,60	5,71	4,52	5,03	5,53	4,16	76,2	105,4
									×	0,27	3,25	4,05	2,52	0,48	3,71	112,7	59,9
										×	2,43	2,39	3,45	4,33	0,30	128,7	145,6
											×	0,72	1,16	2,82	4,58	119,7	128,8
												×	0,02	0,90	2,19	127,3	140,8
													×	1,42	2,06	91,7	96,8
														×	1,99	111,0	109,0

Table 38. **Pulp-woods loss of weight — drying — by different time of felling.**
Massaveds viktförlust — torkning — vid skilda fällningstider.

Method of treatment and stacking Behandlings- och uppläggningssätt	Kind of wood Trädslag	Time of felling (marked with ×) and loss of weight in % of original weight Avverkningstid (markerad med ×) samt viktminskning i % av ursprungsvikt													Water content in % of dry substance weight on the 16/11 Vattenhalt i % av torrsubs. vikt den 16/11	
		10/4	15/4	1/5	15/5	1/6	15/6	1/7	15/7	1/8	15/8	1/9	15/9	1/10	16/11	Root-section rotsekt.	Middle-section mittsekt.
Intact, stored direct upon the ground Obarkat, direkt å marken lagrat	Pine Tall	×		1,16	— 0,97	— 1,54	— 0,77	0,77	1,16	3,71	2,26	1,95	2,43	2,59	3,29 — 2,51	70,3	142,3
			×		0,49	— 1,95	— 4,86	— 1,95	0,49	6,20	4,10	4,27	2,71	3,41	3,37 — 0,88	100,4	175,5
				×		— 0,52	1,05	0,0	4,19	5,86	6,70	5,09	4,45	4,66	2,02 — 3,14	127,8	172,8
					×		1,05	— 1,05	3,50	4,69	3,53	2,35	2,52	1,58	1,45 — 3,60	85,8	119,5
						×		1,00	1,00	4,38	2,40	2,09	3,06	3,55	2,55 2,74	116,8	122,3
							×		1,41	3,92	4,87	5,03	4,59	3,24	2,66 — 2,99	104,5	134,8
								×		3,55	4,61	4,59	3,55	3,53	3,69 — 2,57	123,3	164,0
										×	3,44	2,43	1,40	— 2,26	— 1,92 — 6,73	174,1	181,5
											×	0,06	— 0,18	0,98	0,55 — 2,30	99,7	
												×	— 1,47	1,52	2,52 — 5,26	103,2	114,7
													×	1,69	— 1,77 — 4,50	146,7	147,4
														×	— 1,71 — 7,09	156,7	170,0
															× — 3,95	116,8	111,4
	Spruce Gran	×		0,0	2,65	5,31	2,27	4,54	4,92	9,85	10,34	11,63	11,06	9,33	10,67 6,97	58,0	65,2
			×		1,34	1,00	— 0,33	— 0,67	3,34	10,10	6,84	7,93	5,48	6,91	7,07 3,21	105,0	119,0
				×		— 1,20	1,80	0,30	6,59	8,08	8,81	6,71	6,17	6,86	5,49 4,25	116,3	79,8
					×		2,92	1,95	13,31	11,43	11,64	11,22	10,81	11,05	11,48 6,99	88,1	94,8
						×		2,37	2,66	5,86	4,17	4,05	3,67	5,85	4,94 2,13	90,6	110,3
							×		0,26	4,42	7,03	6,21	5,05	8,46	7,00 3,87	162,7	150,2
								×		1,83	5,02	4,92	2,09	3,00	4,25 0,81	73,9	91,1
										×	2,42	0,71	— 1,21	— 2,71	2,05 — 6,95	99,9	124,9
											×	0,32	— 0,29	0,13	0,60 3,66	71,8	84,0
												×	— 1,20	— 1,71	— 2,13 3,54	100,3	136,0
													×	1.01	1,52 — 3,90	140,0	110,8
														×	0,74 — 3,91	142,0	137,4
															× — 1,46	104,3	115,7

form of treatment half the logs were then put up in airy, so called triangular clips (the logs laid crosswise in triangular form across each other), while the other half were put up in a little heap or stack immediately upon the ground. All storing was done inside the normally close, but newly thinned forest, upon dry ground.

On every occasion of stacking or felling we therefore obtained 6 different types with 10 logs in each, 5 being pine and 5 spruce, viz.:

1) Wholly decorticated timber, put up in airy triangles,
2) » » » , laid direct upon the ground,
3) Stripe-wise stripped timber, put up in airy triangles,
4) » » » , laid direct upon the ground,
5) Intact timber, put up in airy triangles,
6) » » , laid direct upon the ground.

On felling, all logs were weighed and subsequently on every 1st and 15th in each month, right up to the 1st of October, after which a final weighing took place on investigating the test-stacks, which commenced on the 16th November 1923, after the winter had set in with snow and frost.

The result of these weighings will be seen from the Tables 33—38, in which the alterations in weight for all stacks are given in percentage of the original weight. If we study the course of the alterations in weight and the final result in these tables, we shall discover the following features:

1. The wholly decorticated timber, put up in triangles, has, as might have been expected, dried best and it is worthy of note that evaporation was good and considerable in all timber felled as late as the 15th July.

2. The wholly decorticated timber, stored on the ground, felled on the 15th June and earlier, seems to have dried nearly as well as that put up in triangles. Timber felled after the 1st July, however, dried less, and all that had been felled on the 1st August and later had increased in weight.

3. The stripe-wise stripped timber, put up in triangles has throughout dried much better than equally treated timber stored directly on the ground. That felled on the 1st July and earlier has dried very little less than that stored in a similar manner but wholly decorticated, even that felled on the 15th July having dried fairly well, whereas that felled on the 1st September or later has not dried but rather become somewhat heavier.

4. The stripe-wise stripped timber, laid directly on the

ground has dried rather little, and all timber felled on the 15th July and later has increased in weight.

5. The intact timber stored in triangles has dried very slightly, and all felled on the 15th July and later has grown heavier.

6. Of the intact timber stored directly on the ground only spruce displayed some, if even slight, drying as the result of storage, and only such spruce as had been felled on the 15th July and earlier. All pine and spruce felled on the 1st July and later has increased in weight.

Spruce has on the whole dried or lost in weight more than pine, in all forms of storage, and from the tables illustrating the change of weight which the logs undergo it appears that this is due to the previously known fact that pine in damp weather more easily re-absorbs water than spruce.

In order to get some idea of the actual water content at the end of the storage-period, one sample log of spruce and one of pine were taken from every stack for a closer determination of the moisture. These sample logs were taken from the centre of the stacks put up in triangles or laid on the ground, as the case may be, or to be more exact, logs of average dimensions were selected as near the centre of the stack as possible.

From every such log two slabs were sawn out, one about a foot inside the thick end of the log, in the tables designated »root-section», and one in the middle of the log, designated »middle-section». The water content in these samples, stated in percentage of the weight of the dry substance, will be seen from the two last columns in the tables.

As these figures have, however, contrary to the figures for the reduction in weight, been obtained from a single log of each kind of wood in the stack or triangle, too much value must not be attached to them, as the moisture naturally varies in different logs within the same stack.

The storage-damage to the test-material — storage-rot and blueing — was ascertained during November in the following manner:

Two slabs were sawn out of every log, one in the middle and one about a foot from the thick end. Upon these slabs the damaged portions were marked and according to the nature of the damage divided into three degrees of intensity, the blueing thus being indicated in the tables with b, *b* and ***b***, and the storage-rot likewise into three degrees of intensity, viz. r, *r* and ***r***. After that the respective area of the damage was estimated by planimetry, as well as the total area of the slabs. After these areas for the respective forms of storage damage had been summed up, separated with regard to the »root-sections», and to the »middle-sections», the area of the respective damage was set out in % of the total area

of the slabs. These percentages are to be found in the Tables 39—44, distinguished for pine and for spruce, as well as for the position of the section in the middle of the log with »middle section», and at the big-end of the log with »root-section».

A study of these tables proves:

1. That pine throughout in all methods of storage had been damaged more than spruce by both blueing and rot. The difference between pine and spruce is nevertheless in this respect greater when it concerns blueing.

2. That rot in regard to wholly decorticated timber is approximately the same in root-sections and middle-sections; on stripe-wise stripped timber slightly greater in the root-sections than in the middle-sections; and in intact timber very much greater in the root-sections. The fact that rot has thus been less in the middle-sections than in the root-sections, and that this difference has increased in the same measure as bark-stripping had decreased, is probably due to the wood in the sections from the intact logs keeping alive longer, and thus resisting the fungi which consequently get a shorter time in which to develop.

3. That blueing in middle and root-sections on the whole behave like the ravages of rot. In wholly decorticated timber they are thus in the main alike in root and middle-sections from the same logs; in stripe-wise stripped timber there is noticed, especially in spruce, some increase in the root-sections, while, on the other hand, in the case of intact timber the damage is of much greater extent in the root-sections than in the middle-sections.

The cause of this is obviously the obstacle raised to blueing by the somewhat greater moisture in the middle-sections.

4. That blueing, both in regard to its quantitative extent and intensity in pine is on the whole in direct proportion to the degree of drying. The earliest felled, most decorticated and most airily stored timber has thus been most subjected to blueing.

In respect of spruce conditions may certainly on the whole be said to point in the same direction, but one is here struck by certain more pronounced dissimilarities in the occurrence of the blueing. We thus see, especially in the moister forms of storage (see Tables 43 and 44), how a manifest increase in blueing occurred in the timber felled during July and on the 1st August. The reduction in weight for this timber is slight or, in respect of that stored direct upon the ground, negative. If, on the other hand, we look at the moisture content in, for example, the root-sections, we find, however, that the same for the logs in question is nevertheless relatively low, for instance in spruce

Table 39. **Summary of storage-damage to summer-felled pulp-wood, 1923.**
Sammandrag av lagringsskador å sammanhuggen massaved, 1923.

Method of treatment Behandlingsform	Time of felling Avverkningstid	Kind of wood Trädslag	Position of slab of trunk Stamskivans läge	Damage in % of total surface of section Skador i % av snittens totalyta								
				b	*b*	**b**	Total S:a B	r	*r*	**r**	Total S:a R	Total S:a B+R
Wholly decorticated, in triangle Helbarkat i triangel	10/4	pine tall	root-section rotsektion	11,2	46,2	10,8	68,2	1,6	—	—	1,6	69,8
	15/4			4,3	47,8	2,1	54,2	3,9	1,1	2,6	7,6	61,8
	1/5			5,7	14,1	51,2	71,0	—	—	—	—	71,0
	15/5			3,6	18,9	18,1	40,6	—	1,5	—	1,5	42,1
	1/6			3,4	0,9	13,3	17,6	0,1	1,2	—	1,3	18,9
	15/6			—	14,5	25,1	39,6	1,3	1,6	—	2,9	42,5
	1/7			10,2	2,9	26,9	40,0	0,6	—	—	0,6	40,6
	15/7			15,9	4,9	2,6	23,4	10,0	1,6	—	11,6	35,0
	1/8			—	4,8	2,0	6,8	—	0,5	—	0,5	7,3
	15/8			3,9	—	—	3,9	—	—	—	—	3,9
	1/9			—	—	—	—	—	—	—	—	—
	15/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—
	10/4	pine tall	middle-section mittsektion	5,9	59,1	—	65,0	6,1	—	—	6,1	71,1
	15/4			4,9	45,1	—	50,0	9,3	1,3	—	10,6	60,6
	1/5			4,5	57,4	7,2	69,1	—	—	—	—	69,1
	15/5			6,1	18,7	18,4	43,2	—	—	0,2	0,2	43,4
	1/6			—	17,3	5,3	22,6	—	1,5	0,5	2,0	24,6
	15/6			—	—	41,2	41,2	—	—	—	—	41,2
	1/7			—	24,4	9,8	34,2	—	0,7	—	0,7	34,9
	15/7			6,5	3,9	—	10,4	4,3	0,5	—	4,8	15,2
	1/8			0,6	1,3	—	1,9	3,0	3,8	—	6,8	8,7
	15/8			6,9	—	—	6,9	2,4	—	—	2,4	9,3
	1/9			—	—	—	—	—	—	—	—	—
	15/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—
	10/4	spruce gran	root-section rotsektion	17,4	19,3	—	36,7	—	—	—	—	36,7
	15/4			34,4	—	—	34,4	—	7,1	—	7,1	41,5
	1/5			4,0	4,2	—	8,2	—	—	—	—	8,2
	15/5			13,2	—	—	13,2	—	—	—	—	13,2
	1/6			1,2	—	—	1,2	—	—	—	—	1,2
	15/6			—	—	—	—	—	—	—	—	—
	1/7			5,4	1,6	—	7,0	—	—	—	—	7,0
	15/7			2,0	—	2,1	4,1	—	—	—	—	4,1
	1/8			9,2	—	—	9,2	—	0,1	—	0,1	9,3
	15/8			3,3	—	—	3,3	—	—	—	—	3,3
	1/9			—	—	—	—	—	—	—	—	—
	15/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—
	10/4	spruce gran	middle-section mittsektion	36,6	7,0	—	43,6	—	—	—	—	43,6
	15/4			49,3	—	—	49,3	—	—	—	—	49,3
	1/5			22,7	5,2	—	27,9	—	—	—	—	27,9
	15/5			25,2	—	—	25,2	—	—	—	—	25,2
	1/6			3,9	—	—	3,9	—	—	—	—	3,9
	15/6			—	—	—	—	—	—	—	—	—
	1/7			2,8	11,7	—	14,5	—	—	—	—	14,5
	15/7			—	—	—	—	—	—	—	—	—
	1/8			0,1	—	—	0,1	—	—	—	—	0,1
	15/8			—	—	—	—	—	0,2	—	0,2	0,2
	1/9			—	—	—	—	—	—	—	—	—
	15/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—

Table 40. **Summary of storage-damage to summer-felled pulp-wood, 1923.**
Sammandrag av lagringsskador å sommarhuggen massaved, 1923.

Method of treatment / Behandlingsform	Time of felling / Avverkningstid	Kind of wood / Trädslag	Position of slab of trunk / Stamskivans läge	Damage in % of total surface of section. Skador i % av snittens totalyta								
				b	*b*	**b**	Total S:a B	r	*r*	**r**	Total S:a R	Total S:a B+R
Wholly decorticated, on the ground. Helbarkat på marken	10/4	pine tall	root-section rotsektion	7,1	17,8	—	24,9	39,2	6,4	—	45,6	70,5
	15/4			4,3	33,6	4,3	42,2	7,4	15,2	2,6	25,2	67,4
	1/5			6,1	0,7	12,2	19,0	11,4	5,6	1,2	18,2	37,2
	15/5			—	0,8	—	0,8	40,1	2,4	—	42,5	43,3
	1/6			0,3	0,3	6,0	6,6	4,1	15,3	0,4	19,8	26,4
	15/6			13,9	4,3		18,2	8,5	1,3	—	9,8	28,0
	1/7			1,1	6,3	6,8	14,2	1,9	1,6	0,4	3,9	18,1
	15/7			1,2	1,1	14,4	16,7	—	—	—	—	16,7
	1/8			—	—	—	—	0,2	0,1	—	0,3	0,3
	15/8			—	—	—	—	—	—	—	—	—
	1/9			—	—	—	—	—	—	—	—	—
	15/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—
	10/4	pine tall	middle-section mittsektion	15,8	7,5	3,7	27,0	19,8	16,7	2,2	38,7	65,7
	15/4			5,3	25,6	2,6	33,5	22,5	3,4	0,6	26,5	60,0
	1/5			14,0	7,6	0,8	22,4	6,6	9,4		16,0	38,4
	15/5			2,9	1,1		4,0	31,6	5,2	0,8	37,6	41,6
	1/6			0,3	1,1	0,7	2,1	1,2	7,8		9,0	11,1
	15/6			1,9		1,0	2,9	33,2	7,5		40,7	43,6
	1/7			0,7	4,5	1,7	6,9	—	1,4	0,7	2,1	9,0
	15/7			—	—	1,3	1,3	—	—	—	—	1,3
	1/8			—	—	—	—	—	—	—	—	—
	15/8			—	—	—	—	—	—	—	—	—
	1/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—
	10/4	spruce gran	root-section rotsektion	—	—	—	—	2,6	3,7	—	6,3	6,3
	15/4			23,8	6,1	—	29,9	9,1	—	—	9,1	39,0
	1/5			3,4	—	—	3,4	5,4	20,8	—	26,2	29,6
	15/5			—	—	—		2,7	0,7	—	3,4	3,4
	1/6			5,2	—	—	5,2	—	1,7	—	1,7	6,9
	15/6			2,2	3,4	—	5,6	0,3	6,2	—	6,5	12,1
	1/7			3,1	0,1	—	3,2	2,4	13,1	0,4	15,9	19,1
	15/7			5,7	—	—	5,7	2,5	—	—	2,5	8,2
	1/8			—	—	—	—	—	—	—	—	—
	15/8			—	—	—	—	—	—	—	—	—
	1/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—
	10/4	spruce gran	middle-section mittsektion	0,6	0,1	—	0,7	—	—	—	—	0,7
	15/4			37,1	6,1	—	43,2	1,3	—	—	1,3	44,5
	1/5			1,9	—	—	1,9	1,4	2,9	0,5	4,8	6,7
	15/5			—	12,7	—	12,7	0,2	0,2	—	0,4	13,1
	1/6			4,3	—	—	4,3	—	2,8	—	2,8	7,1
	15/6			1,0	0,8	—	1,8	2,9	—	—	2,9	4,7
	1/7			—	—	—	—	5,0	—	0,6	5,6	5,6
	15/7			0,6	—	—	0,6	—	—	—	—	0,6
	1/8			—	—	—	—	—	—	—	—	—
	15/8			—	—	—	—	1,4	—	—	1,4	1,4
	1/9			—	—	—	—	—	—	—	—	—
	15/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—

Table 41. **Summary of storage-damage to summer-felled pulp-wood, 1923.**
Sammandrag av lagringsskador å sommarhuggen massaved, 1923.

Method of treatment Behandlingsform	Time of felling Avverkningstid	Kind of wood Trädslag	Position of slab of trunk Stamskivans läge	Damage in % of total surface of section Skador i % av snittens totalyta								
				b	*b*	**b**	Total S:a B	r	*r*	**r**	Total S:a R	Total S:a B+R
Stripe-wise stripped, in triangle Randbarkat i triangel	10/4	pine tall	root-section rotsektion	1,9	9,1	2,2	13,2	38,6	2,6	0,6	41,8	55,0
	15/4			3,2	3,5	—	6,7	27,7	15,9	—	43,6	50,3
	1/5			0,4	2,5	1,8	4,7	34,7	14,1	0,4	49,2	53,9
	15/5			2,3	0,2	1,1	3,6	6,5	16,3	—	22,8	26,4
	1/6			0,5	3,2	—	3,7	34,2	6,9	—	41,1	44,8
	15/6			2,9	1,6	12,9	17,4	5,1	10,7	0,9	16,7	34,1
	1/7			0,6	1,8	15,8	18,2	—	1,4	0,4	1,8	20,0
	15/7			0,1	3,5	5,9	9,5	5,3	4,7	—	10,0	19,5
	1/8			—	1,5	—	1,5	15,2	—	2,2	17,4	18,9
	15/8			0,5	1,2	1,3	3,0	—	0,7	—	0,7	3,7
	1/9			—	—	—	—	—	—	—	—	—
	15/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—
	10/4	pine tall	middle-section mittsektion	2,5	8,7	1,2	12,4	4,0	7,6	0,2	11,8	24,2
	15/4			4,2	14,2	3,8	22,2	11,8	4,6	—	16,4	38,6
	1/5			0,8	2,7	—	3,5	26,7	4,7	—	31,4	34,9
	15/5			0,2	1,3	3,7	5,2	14,1	9,3	—	23,4	28,6
	1/6			—	2,1	—	2,1	8,7	7,3	—	16,0	18,1
	15/6			2,2	1,3	0,3	3,8	10,7	5,3	—	16,0	19,8
	1/7			0,7	0,6	2,0	3,3	1,4	1,5	—	2,9	6,2
	15/7			—	0,4	—	0,4	5,8	2,5	—	8,3	8,7
	1/8			—	0,4	—	0,4	—	—	—	—	0,4
	15/8			—	—	—	—	—	—	—	—	—
	1/9			—	0,1	—	0,1	—	—	—	—	0,1
	15/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—
	10/1	spruce gran	root-section rotsektion	1,5	0,4	—	1,9	—	—	—	—	1,9
	15/1			—	0,9	—	0,9	—	3,9	2,3	6,2	7,1
	1/5			0,5	—	—	0,5	5,5	1,8	—	7,3	7,8
	15/5			2,5	—	—	2,5	—	0,8	11,0	11,8	14,3
	1/6			0,8	—	—	0,8	6,2	3,5	0,5	10,2	11,0
	15/6			—	—	—	—	—	0,3	4,9	5,2	5,2
	1/7			4,3	0,5	—	4,8	—	0,3	0,3	0,6	5,4
	15/7			0,2	0,3	—	0,5	—	3,2	—	3,2	3,7
	1/8			0,6	15,6	2,1	18,3	23,5	2,0	0,2	25,7	44,0
	15/8			12,0	6,5	—	18,5	0,2	2,3	—	2,5	21,0
	1/9			—	—	—	—	4,5	0,1	—	4,6	4,6
	15/9			—	—	0,5	0,5	—		—	—	0,5
	1/10			—	—	—	—	—	—	—	—	—
	10/4	spruce gran	middle-section mittsektion	0,7	—	—	0,7	—	0,2	—	0,2	0,9
	15/4			1,7	—	—	1,7	—	0,2	—	0,2	1,9
	1/5			1,3	0,3	—	1,6	5,6	0,1	0,7	6,4	8,0
	15/5			0,7	1,8	—	2,5	0,6	4,4	—	5,0	7,5
	1/6			0,2	0,4	—	0,6	1,0	1,5	—	2,5	3,1
	15/6			—	—	—		0,2	—	—	0,2	0,2
	1/7			0,4	—	—	0,4	0,3	—	—	0,3	0,7
	15/7			—	—	—	—	—	0,5	—	0,5	0,5
	1/8			1,1	1,8	—	2,9	6,1	—	2,9	9,0	11,9
	15/8			1,7	3,4	—	5,1	0,2	—	—	0,2	5,3
	1/9			0,1	—	—	0,1	—	—	0,1	0,1	0,2
	15/9			—	—	0,5	0,5	—	—	—	—	0,5
	1/10			—	—	—	—	—	—	—	—	—

Table 42. **Summary of storage-damage to summer-felled pulp-wood, 1923.**
Sammandrag av lagringsskador å sommarhuggen massaved, 1923.

Method of treatment Behandlingsform	Time of felling Avverknings-tid	Kind of wood Trädslag	Position of slab of trunk Stamskivans läge	Damage in % of total surface of section Skador i % av snittens totalyta								
				b	*b*	**b**	Total S:a B	r	*r*	**r**	Total S:a R	Total S:a B+R
Stripe-wise stripped, on the ground Randbarkat på marken	10/4	pine tall	root-section rotsektion	3,5	1,2	—	4,7	38,7	4,7	0,9	44,3	49,0
	15/4			5,0	0,4	—	5,4	5,5	19,9	1,3	26,7	32,1
	1/5			1,5	3,1	—	4,6	51,4	12,9	—	64,3	68,9
	15/5			0,4	0,6	—	1,0	19,3	10,8	—	30,1	31,1
	1/6			3,7	9,2	—	12,9	10,9	1,4	—	12,3	25,2
	15/6			—	2,2	13,7	15,9	10,9	3,8	—	14,7	30,6
	1/7			3,9	2,9	14,0	20,8	1,1	0,2	—	1,3	22,1
	15/7			0,1	1,6	0,5	2,2	3,3	—	—	3,3	5,5
	1/8			0,8		4,3	5,1	—	—	—	—	5,1
	15/8			0,1	1,2	6,2	7,5	1,4	—	—	1,4	8,9
	1/9			—	—	—	—	—	—	—	—	—
	15/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—
	10/4	pine tall	middle-section mittsektion	3,3	—	2,7	6,0	2,9	6,7	—	9,6	15,6
	15/4			6,5	0,9	—	7,4	4,0	13,8	0,2	18,0	25,4
	1/5			—	0,3	—	0,3	3,3	6,1	—	9,4	9,7
	15/5			—	0,4	0,7	1,0	3,9	3,2	—	7,1	8,2
	1/6			0,8	6,7	—	7,5	3,8	—	—	3,8	11,3
	15/6			0,1	0,8	—	0,9	3,0	0,1	—	3,1	4,0
	1/7			0,4	1,5	0,1	2,0	1,3	—	—	1,3	3,3
	15/7			—	0,7	0,7	1,4	4,1	—	—	4,1	5,5
	1/8			—	0,4	—	0,4	2,1	0,4	—	2,5	2,9
	15/8			0,3	0,6	—	0,9	0,2	—	—	0,2	1,1
	1/9			—	—	—	—	—	—	—	—	—
	15/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—
	10/4	spruce gran	root-section rotsektion	1,1	—	—	1,1	0,5	6,3	2,5	9,3	10,4
	15/4			—	—	—		28,2	12,6	9,8	50,6	50,6
	1/5			0,6	—	—	0,6	5,0	2,8	1,6	9,4	10,0
	15/5			0,5	—	—	0,5	21,5	0,1	0,5	22,1	22,6
	1/6			—	—	—	—	1,2	—	—	1,2	1,2
	15/6			7,4	2,6	3,1	13,1	10,4	0,3	—	10,7	23,8
	1/7			11,9	—	—	11,9	—	1,6	—	1,6	13,5
	15/7			10,8	6,1	—	16,9	—	0,3	—	0,3	17,2
	1/8			0,3	1,3	—	1,6	19,3	—	—	19,3	20,9
	15/8			—	2,4	—	2,4		0,3	—	0,3	2,7
	1/9			—	—	—	—	—	—	—	—	—
	15/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—
	10/4	spruce gran	middle-section mittsektion	—	—	—	—	2,3		—	2,3	2,3
	15/4			—	—	—	—	1,8	3,7	—	5,5	5,5
	1/5			—	—	—	—	—	0,7	—	0,7	0,7
	15/5			—	—	0,6	0,6	0,5	12,3	—	12,8	13,4
	1/6			0,8	—	—	0,8	—	—	—	—	0,8
	15/6			2,5	4,5	1,1	8,1	0,6	—	—	0,6	8,7
	1/7			—	—	—	—	—	—	—	—	—
	15/7			—	0,2	—	0,2	1,1	—	—	1,1	1,3
	1/8			—	0,1	—	0,1		—	—	—	0,1
	15/8			0,9	—	—	0,9	0,2	—	—	0,2	1,1
	1/9			—	—	—	—	1,2	0,2	—	1,4	1,4
	15/9			—	—	—	—	1,0	—	—	1,0	1,0
	1/10			—	—	—	—	—	—	—	—	—

Table 43. **Summary of storage-damage to summer-felled pulp-wood, 1923.**
Sammandrag av lagringsskador å sommarhuggen massaved, 1923.

Method of treatment Behandlingsform	Time of felling Avverknings-tid	Kind of wood Trädslag	Position of slab of trunk Stamskivans läge	Damage in % of total surface of section Skador i % av snittens totalyta								
				b	*b*	**b**	Total S:a B	r	*r*	**r**	Total S:a R	Total S:a B+R
Intact, in triangle Obarkat i triangel	$^{10}/_{4}$	pine tall	root-section rotsektion	2,0	4,9	3,2	10,1	15,2	13,1	0,4	28,7	38,8
	$^{15}/_{4}$			0,1	4,7	8,3	13,1	26,0	21,6	0,2	47,8	60,9
	$^{1}/_{5}$			1,1	2,3	3,5	6,9	7,7	50,3	0,5	58,5	65,4
	$^{15}/_{5}$			0,6	0,3	12,3	13,2	39,3	23,4	3,6	66,3	79,5
	$^{1}/_{6}$			2,6	3,5	—	6,1	13,4	0,3	—	13,7	19,8
	$^{15}/_{6}$			1,5	3,3	—	4,8	25,6	0,9	—	26,5	31,3
	$^{1}/_{7}$			0,8	4,2	8,2	13,2	0,1	0,8	—	0,9	14,1
	$^{15}/_{7}$			—	0,1	1,7	1,8	—	0,9	—	0,9	2,7
	$^{1}/_{8}$			—	4,2	5,7	9,9	—	—	—	0,2	9,9
	$^{15}/_{8}$			0,3	6,4	1,5	8,2	—	0,2	—	—	8,4
	$^{1}/_{9}$			—	—	—	—	—	—	—	—	—
	$^{15}/_{9}$			—	—	—	—	—	—	—	—	—
	$^{1}/_{10}$			—	—	—	—	—	—	—	—	—
	$^{10}/_{4}$	pine tall	middle-section mitttsktion	0,5	0,5	6,9	7,9	—	2,8	—	2,8	10,7
	$^{15}/_{4}$			0,7	3,3	2,1	6,1	2,4	1,3	1,1	4,8	10,9
	$^{1}/_{5}$			—	0,5	1,8	2,3	1,5	—	—	1,5	3,8
	$^{15}/_{5}$			—	0,4	—	0,4	2,4	1,2	—	3,6	4,0
	$^{1}/_{6}$			1,1	—	—	1,1	1,2	—	—	1,2	2,3
	$^{15}/_{6}$			—	—	—	—	0,2	1,0	—	1,2	1,2
	$^{1}/_{7}$			0,2	—	—	0,2	—	—	—	—	0,2
	$^{15}/_{7}$			—	0,3	—	0,3	—	—	—	—	0,3
	$^{1}/_{8}$			0,7	1,1	0,4	2,2	—	—	—	—	2,2
	$^{15}/_{8}$			1,5	—	—	1,5	—	—	—	—	1,5
	$^{1}/_{9}$			—	—	—	—	—	—	—	—	—
	$^{15}/_{9}$			—	—	—	—	—	—	—	—	—
	$^{1}/_{10}$			—	—	—	—	—	—	—	—	—
	$^{10}/_{4}$	spruce gran	root-section rotsektion	1,0	0,7	—	1,7	3,9	6,7	1,7	12,3	14,0
	$^{15}/_{4}$			7,1	0,7	0,3	8,1	19,6	0,3	—	19,9	28,0
	$^{1}/_{5}$			—	—	—	—	6,1	7,2	0,9	14,2	14,2
	$^{15}/_{5}$			—	—	—	—	5,7	7,7	14,5	27,9	27,9
	$^{1}/_{6}$			19,4	—	—	19,4	39,1	2,0	—	41,1	60,5
	$^{15}/_{6}$			3,8	—	—	3,8	39,2	0,7	—	39,9	43,7
	$^{1}/_{7}$			9,4	3,2	—	12,6	—	—	—	—	12,6
	$^{15}/_{7}$			0,9	—	1,9	2,8	—	0,9	—	0,9	3,7
	$^{1}/_{8}$			—	40,0	4,3	44,3	5,2	—	—	5,2	49,5
	$^{15}/_{8}$			8,2	6,8	—	15,0	0,1	—	—	0,1	15,1
	$^{1}/_{9}$			—	—	—	—	—	—	—	—	—
	$^{15}/_{9}$			—	—	—	—	—	—	—	—	—
	$^{1}/_{10}$			—	—	—	—	—	—	—	—	—
	$^{10}/_{4}$	spruce gran	middle-section mittsektion	1,8	0,9	—	2,7	0,5	—	—	0,5	3,2
	$^{15}/_{4}$			0,3	0,6	—	0,9	0,2	0,3	—	0,5	1,4
	$^{1}/_{5}$			—	—	—	—	—	0,1	—	0,1	0,1
	$^{15}/_{5}$			—	0,8	1,8	2,6	—	0,9	0,4	1,3	3,9
	$^{1}/_{6}$			7,7	3,3	—	11,0	7,8	—	—	7,8	18,8
	$^{15}/_{6}$			—	1,0	—	1,0	0,3	—	—	0,3	1,3
	$^{1}/_{7}$			—	—	—	—	—	—	—	—	—
	$^{15}/_{7}$			—	—	—	—	—	—	—	—	—
	$^{1}/_{8}$			0,6	1,9	—	2,5	—	—	—	—	2,5
	$^{15}/_{8}$			1,2	—	0,3	1,5	—	—	0,9	0,9	2,4
	$^{1}/_{9}$			—	—	—	—	—	—	—	—	—
	$^{15}/_{9}$			—	—	—	—	—	—	—	—	—
	$^{1}/_{10}$			—	—	—	—	—	—	—	—	—

Table 44. **Summary of storage-damage to summer-felled pulp-wood, 1923.**
Sammandrag av lagringsskador å sommarhuggen massaved, 1923.

Method of treatment / Behandlingsform	Time of felling / Avverkningstid	Kind of wood / Trädslag	Position of slab of trunk / Stamskivans läge	Damage in % of total surface of section / Skador i % av snittens totalyta								
				b	*b*	**b**	Total S:a B	r	*r*	**r**	Total S:a R	Total S:a B+R
Intact, on the ground / Obarkat på marken	10/4	pine tall	root-section rotsektion	—	0,5	3,5	4,0	35,8	18,7	—	54,5	58,5
	15/4			2,7	—	—	2,7	5,3	31,0	—	36,3	39,0
	1/5			—	—	0,4	0,4	19,4	28,9	—	48,3	48,7
	15/5			—	—	—	—	12,0	35,4	—	47,4	47,4
	1/6			—	0,6	—	0,6	23,2	29,8	—	53,0	53,6
	15/6			—	—	8,2	8,2	9,6	—	—	9,6	17,8
	1/7			—	3,4	15,7	19,1	—	0,3	—	0,3	19,4
	15/7			—	0,4	5,6	6,0	—	—	—	—	6,0
	1/8			—	4,4	4,3	8,7	—	—	—	—	8,7
	15/8			1,3	—	2,6	3,9	—	—	—	—	3,9
	1/9			—	—	—	—	—	—	—	—	—
	15/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—
	10/4	pine tall	middle-section mittsektion	—	0,1	—	0,1	9,6	—	—	9,6	9,7
	15/4			—	0,6	—	0,6	1,4	—	—	1,4	2,0
	1/5			—	—	—	—	21,2	—	—	21,2	21,2
	15/5			—	—	—	—	—	—	—	—	—
	1/6			0,3	—	—	0,3	3,4	—	—	3,4	3,7
	15/6			—	—	—	—	—	—	—	—	—
	1/7			0,4	0,9	—	1,3	3,1	—	—	3,1	4,4
	15/7			0,1	—	—	0,1	—	—	—	—	0,1
	1/8			—	0,3	—	0,3	—	—	—	—	0,3
	15/8			0,9	—	—	0,9	—	—	—	—	0,9
	1/9			—	—	—	—	—	—	—	—	—
	15/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—
	10/4	spruce gran	root-section rotsektion	—	—	—	—	20,6	7,4	2,0	30,0	30,0
	15/4			0,4	—	—	0,4	8,8	10,9	0,3	20,0	20,4
	1/5			22,7	—	—	22,7	10,2	0,8	—	11,0	33,7
	15/5			—	—	—	—	25,1	10,1	0,2	35,4	35,4
	1/6			1,6	3,4	—	5,0	9,9	1,9	—	11,8	16,8
	15/6			4,2	—	—	4,2	9,9	8,6	—	18,5	22,7
	1/7			8,7	14,9	—	23,6	0,7	1,8	—	2,5	26,1
	15/7			4,0	3,3	10,5	17,8	—	7,3	0,9	8,2	26,0
	1/8			6,5	21,6	1,7	29,8	—	—	—	—	29,8
	15/8			9,0	3,4	—	12,4	1,4	0,2	—	1,6	14,0
	1/9			—	—	—	—	—	—	—	—	—
	15/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—
	10/4	spruce gran	middle-section mittsektion	—	—	—	—	30,7	1,5	—	32,2	32,2
	15/4			—	—	—	—	0,2	—	—	0,2	0,2
	1/5			—	—	—	—	0,1	0,2	—	0,3	0,3
	15/5			—	—	—	—	—	—	—	—	—
	1/6			—	—	—	—	—	—	—	—	—
	15/6			0,9	—	—	0,9	—	0,8	—	0,8	1,7
	1/7			—	—	—	—	—	0,1	—	0,1	0,1
	15/7			—	—	—	—	—	—	—	—	—
	1/8			—	—	—	—	—	—	—	—	—
	15/8			—	1,0	—	1,0	—	0,4	—	0,4	1,4
	1/9			—	—	—	—	—	—	—	—	—
	15/9			—	—	—	—	—	—	—	—	—
	1/10			—	—	—	—	—	—	—	—	—

felled on the 1st July, 15th July and 1st August (see Table 38) respectively 73,9 % 99,9 % and 71,8 %, and the blueing damage in these sections is in direct proportion to the degree of dryness (see Table 44) with 23 %, 17 % and 29 % respectively of the section-surface concerned.

This seems to confirm our aforesaid surmise (cf. p. 620) that the cause of summerfelled timber in some instances being liable to blueing in a greater measure than winter-felled, is that the summer-felled timber possess a lower original water content.

In this connection it should, maybe, also be pointed out that the very surface of the summer-felled timber frequently assumes a darker colour through blueing than the surface of timber felled in winter or early in spring also in such case where the blueing further within the wood displays a minor difference.

The cause of this may be surmised as due to the fact that the surface of the early-felled timber, before any extensive infection by blueing fungi has come about in summer, on several occasions has dried rather much and again moistened, a condition which, in agreement with laboratory tests, appears to present diminished possibilities for the development of the blueing fungi.

5. That all timber felled on the 1st September and later on the whole is free from blueing.

6. That storage-rot in direct opposition to what is the case with blueing is more intensely developed in the moister forms of storage, and least in the dry forms. In spruce storage-rot is practically entirely absent in the case of wholly decorticated timber, stored in a triangle.

7. That in spite of better evaporation in stripe-wise stripped timber storage-rot is yet almost equally as prevalent as in intact timber.

This feature may possibly be connected with the fact that the undamaged and still living bark forms an obstacle to the penetration of the fungi.

It should furthermore be observed that on a stripe-wise stripped log the blueing is on the whole found to be concentrated upon those portions of the wood over which the bark has been removed while, on the other hand, storage-rot chiefly occurs in the wood below the adhering bark. As the adhering bark in this instance is dead, the distribution of the various kinds of damage in the timber must be entirely connected with the varying moisture content in the wood below and between the stripes of bark.

8. That storage-rot is also absent in all forms of stacking timber felled on the 1st September or later.

* * *

As timber felled on the 1st September or later had not been attacked in any shape or form by damage in the first year, but wholly decorticated and airily stored stripe-wise stripped timber nevertheless dried to some extent already in the first year, it should be interesting to see how timber would behave during the ensuing summer's storage in respect of the occurrence of damage. For this purpose there were repeated in 1924 by Mr ENANDER the tests carried out by us with pulp-wood stripe-wise stripped and wholly decorticated. In order to arrive at the further criterion for the time of felling at which the storage-damage ceases for the year, these fellings and stackings were commenced as early as the 15th June, 1924, and then continued on the 1st and 15th of each month, right up to the 15th November.

The tests embraced only wholly decortitated or stripe-wiese stripped timber, put up in triangle stacks, and carried out in the same stand and along the same lines as those adopted by us in 1923.

The weighing of the felled timber was, furthermore, carried out on the occasion of felling and on the 1st och 15th of every succeding month, right up to the 15th October, 1925, and thereupon on the 15th of each month from April, 1925, until September of the same year.

The changes in weight recorded on these occasions will be seen from Table 45, in which the original weight has been put down as 100, and the ensuing weights on various occasions of weighing are stated in percentage on the original weight. No direct moisture-tests were, however, made with these logs.

Regarding the evaporation Mr ENANDER has, beyond that which is directly apparent from Table 45, ascertained the following through detailed treatment of the material weighed:

Evaporation of the smaller logs proceeds much more rapidly than that of the stouter ones.

With a variation of diameter between 7 and 13 cm. the difference in evaporation during a summer-month was found for logs of different thickness to amount to: wholly decorticated timber 2,7 % and stripe-wise stripped timber 1,7 % for every change of 1 cm. in diameter. On inspecting the weights on the 25th October, 1924, after evaporation for the year had ceased, the difference in weight of the wholly decorticated wood was 2,1 % of the original weight for every variation of 1 cm. in diameter, while the corresponding figure for the stripe-wise stripped wood stopped at 1,6 %.

At the final inspection on the 15th September, 1925, after the wood had dried further during a summer, the weight in percentage of the

Table 45. **Variations in weight of pulp-wood felled during the year 1924.**
Raw-weight = 100.

Viktvariationerna hos massaved, avverkad under år 1924.
Råvikt = 100.

Treatment. Behandling	Average diameter. Medeldiam. cm.	Date on which weighed. Dag för vägning	1924									1925					
			15/6	1/7	15/7	1/8	15/8	1/9	15/9	1/10	15/10	15/4	15/5	15/6	15/7	15/8	15/9
Spruce, wholly decorticated, in triangle. Helbarkad gran i triangel	9,7	15/6	100	75	67	60	63	63	66	66	67	65	63	61	62	63	65
	10,5	1/7		100	89	80	66	64	62	62	62	58	52	55	52	56	58
	10,1	15/7			100	78	67	63,5	65	64	65	65	64	61,5	62	61	62
	11,9	1/8				100	90	80	75	72	71	69	66	57	57	56	56
	10,5	15/8					100	81	69	64	61	59	57	56	57	58	57
	8,2	1/9						100	95	92	91	81	64	59	60	56	60
	10,7	15/9							100	94	94	78	65	57	59	58	57
	9,1	1/10								100	101	75	64	59	56	59	60
	10,2	15/10									100	84	73	63	61	62	63
	8,2	1/11										74	63	61	57	61	60
	9,1	15/11										77	66	60	55	62	60
Spruce, stripe-wise stripped, in triangle. Randbarkad gran i triangel	11,7	15/6	100	90	82	78	75	73	72	69	69	69	66	61	62	60	60
	13,5	1/7		100	95	90	85	82	81	79	79	79	75	67	64	61	62
	11,2	15/7			100	92	84	82	77	76	76	76	70	63	64	62	61
	9,6	1/8				100	91	87	85	83	82	80	76	62	61	59	59
	11,0	15/8					100	92	85,5	85	84,5	76	72	64	65	60	59
	9,8	1/9						100	96	92	91	88	82	73	73	64	63,5
	9,8	15/9							100	98	99	97	88	71	68	59	59
	9,1	1/10								100	102	94	87	65	65	56	55
	8,9	15/10									100	93	84	68	63	62	61
	9,5	1/11										92	84	69	66	61	60
	10,0	15/11										94	89	75	73	62	60
Pine, wholly decorticated, in triangle. Helbarkad tall i triangel	9,5	15/6	100	74	62	57	58	58	61	61	63	64	61	56	58	60	63
	10,9	1/7		100	84	76	61	60	63	64	64	65	59	57	56	61	60
	9,7	15/7			100	74	61	60	61	62	63	64	62	57	57	59	60
	9,5	1/8				100	88	69	67	65	67	65	59	60	61	61	61
	10,1	15/8					100	68	62	54	55	53	49	46	47	49	51
	9,9	1/9						100	95	92	92	94	80	61	59	57	60
	9,2	15/9							100	96	97	84	73	57	58	57	57
	9,2	1/10								100	100	87	79	58	55	59	59
	10,0	15/10									100	88	75	61	55	58	58
	9,4	1/11										81	70	60	58	59	59
	10,6	15/11										81	74	59	55	55	55
Pine, stripe-wise stripped in triangle. Randbarkad tall i triangel	10,0	15/6	100	90	83	76	74	73	70	69	69	73	68	61	60	59	61
	10,4	1/7		100	93	86	81	79	76	76	77	82	73	63	62	59	61
	10,3	15/7			100	91	83	82	79	78	79	88	80	68	68	62	61
	12,1	1/8				100	94	89	88	86	87	94	83	67	66	60	59
	11,2	15/8					100	94	88	88	90	89	87	78	78	70	68
	10,5	1/9						100	96	92	93	95	89	75	72,5	65,5	66
	8,9	15/9							100	98	98,5	105	96	76	72	64	63
	9,2	1/10								100	101	100	90	71	72	64	62,5
	9,1	15/10									100	101	93	77	74	69	66
	8,9	1/11										96	90	75	72	67	65
	10,8	15/11										97	93	83	81	73	70

original weight, with an average diameter of 10 cm. at the top of wholly decorticated pine was 59,8 %, for wholly decorticated spruce 60 %, for stripe-wise stripped pine 62,5 %, and for stripe-wise stripped spruce 60,5 %.

The degree of evaporation in wholly decorticated wood was at that time found to be independent of the diameter — consequently carried to the utmost — while, on the other hand, in partly decorticated wood it diminished somewhat in the stouter sizes, and this especially in pine, where the diminution was 1,5 % for each increase of 1 cm. in diameter.

In comparison with the original weight wholly decorticated pine lightened slightly more than spruce under equal evaporation conditions. On an average the relative decrease in the weight of pine stacked in 1924 to that of spruce was as 1,05: 1.

With regard to partly decorticated wood, on the other hand, spruce displayed a greater reduction in weight than pine, besides which the latter had absorbed more water during winter-storage than spruce. After the end of the second summer-storage stripe-wise stripped spruce had on an average lightened 1,05 times more than equally treated pine, in which latter the variations in diminution of weight between logs of different sizes was likewise greater.

The estimation of storage-damage to the various stacks was effected partly on the 24th October, 1924, when only 2 spruce and 2 pine-logs from each stack were removed and cut into sections for ascertaining the damage, and partly at a final investigation on the 14th to the 16th September, 1925, when all remaining logs from the stacks were investigated.

This investigation was carried out on three cross-sections of logs, designated in Tables 46—49 with I, II and III. Sections I and III were taken 30 cm. within the respective end of the log, II in the middle. The damage was divided into three degrees of intensity, designated in the tables with respectively 1 for the feeblest and 3 for the severest form. Blueing is marked b and storage-rot r. In the majority of sections both blueing and rot were, however, discovered, which, moreover, after the second summer-storage mostly were difficult to separate, wherefore they were classed together under the designation br. This has been done throughout in the columns which indicate the damage with different degress of intensity in percentage of extent of the sapwood surface examined. It should be specially pointed out that the extent of the damage has been given in % of the sapwood in contradistinction to what was done in the previous tables, where the damage has been given in % of the whole surface of section.

In order to obtain comparative figures between the extent of damage on the occasion of the first and last examination, the extent of the damage in percentage of the sapwood-surface has been multiplied by 3 when it was of the highest degree of intensity, by 2 when it was of the second and by 1 when of the first. These products have then been added and the totals are the comparative figures for the damage stated in the tables.

If we take a closer look at the result of this storage-series, such as manifested by the records taken at the investigation and then brought together in Tables 46—49, we find that the experiences gained in our storage of pulp-wood in 1923 are confirmed.

Thus even during 1924 no damage has occured to timber felled on the 1st September or later.[1]

The damage to pine during 1924 consists in the wholly decorticated logs chiefly of blueing, the extent of which is in direct proportion to the evaporation or loss of weight, and is consequently greater in the earliest felled timber. In the stripe-wise stripped pine logs the blueing is less intense, but they have on the other hand got some rot.

The wholly decorticated spruce is during the first year practically intact of damage, whilst that partly decorticated is slightly attacked by rot, and also by slight blueing on the July-felled wood.

When stored over another summer, pine is found to be very severely damaged under practically all forms of storage and periods of felling.

Although this is not directly evident from the tables, it was noticed that during the second year the wholly decorticated wood was chiefly attacked by blueing, while in the partly decorticated wood rot predominated. On account of the method of calculating the comparative figures blueing and rot have been allowed to weigh equally in the tables, but as in partly decorticated wood (Table 48) rot predominates, whereas in the wholly decorticated one (Tables 46) blueing has caused the chief damage, the value of the partly decorticated timber has been much more reduced in comparison with wholly decorticated than is manifest from the comparative figures.

The stripe-wise stripped pine, stored over till next year, is on the whole entirely useless both as pulp-wood and pit-props, whereas the wholly decorticated wood, though reduced in value by blueing, must yet be considered usable as sulphate wood and pit-props.

The spruce kept over till next year was found, when stripe-wise

[1] The same test-series as in 1924 were again laid up in 1925 by Mr. ENANDER, but their result cannot be included here for lack of space. The result points, however, in every particular in the same direction, the damage nevertheless ceasing this year already on felling on the 15th August.

Table 46. **Investigations into damage to stored round timber.**
Summary of amount and intensity of damage on the 15th September, 1925.

Undersökning av skador på lagrat rundvirke.
Sammanfattning av skadornas omfattning och styrka den 15. 9. 1925.

Kind of wood: Pine. Treatment: Wholly decorticated. Method of stacking: In a triangle
Trädslag: Tall. Behandling: Helbarkat. Upplägningssätt: I triangel.

Date of felling in the year 1924 Avverkning år 1924 den	Intensity of damage Skadans styrka	Attack in % of number of sections investigated in section Angrepp i % av antal undersökta snitt vid sektion			Total amount of damage Summa skada								Comparative figures for damage in the year Jämförelsetal för skadan år	
					in % of sections investigated i % av undersökta snitt				in % of surface of sapwood-section investigated i % av undersökt splintsnittyta				1924 on the 24/10 1924 den 24/10	1925 on the 15/9 1925 den 15/9
		I	II	III	Intensity styrka 1	2	3	Total S:a	Intensity styrka 1	2	3	Total S:a		
15/6	1													
	2	b 67												
	3	b 33	b 100	b 100		22	78	100		2	37	39	220	278
1/7	1			br 33										
	2													
	3	br 100	br 100	br 67	11		89	100	2		70	72	170	278
15/7	1													
	2		b 67											
	3	b 100	b 33	b 100		22	78	100		15	72	87	110	278
1/8	1													
	2													
	3	br 100	br 100	br 100			100	100			97	97	90	300
15/8	1													
	2	br 100	br 67	br 67										
	3		br 33	br 33		78	22	100		44	19	63	80	222
1/9	1													
	2	br 33	br 33											
	3	br 67	br 67	br 100		22	78	100		20	70	90	0	278
15/9	1													
	2	br 67	br 67	br 67										
	3	br 33	br 33	br 33		67	33	100		39	27	66	0	233
1/10	1													
	2													
	3	br 100	br 100	br 100			100	100			92	92	0	300
15/10	1													
	2		br 33	br 33										
	3	br 100	br 67	br 67		22	78	100		22	76	98	0	278
1/11	1													
	2	br 33	br 33	br 33										
	3	br 67	br 67	br 67		33	67	100		15	40	55	0	267
15/11	1													
	2	br 33	br 33	br 33										
	3	br 67	br 67	br 67		33	67	100		27	39	66	0	267

Table 47. **Investigations into damage to stored round timber.**

Summary of amount and intensity of damage on the 15th September, 1925.

Undersökning av skador på lagrat rundvirke.

Sammanfattning av skadornas omfattning och styrka den 15. 9. 1925.

Kind of wood: Spruce. Treatment: Wholly decorticated. Method of stacking: In a triangle.
Trädslag: Gran. Behandling: Helbarkat. Uppläggningssätt: I triangel.

Date of felling in the year 1924 Avverkning år 1924 den	Intensity of damage Skadans styrka	Attack in % of number of sections investigated in section Angrepp i % av antal undersökta snitt vid section			Total amount of damage Summa skada							Comparative figures for damage in the year Jämförelsetal för skadan år	
					in % of sections investigated i % av undersökta snitt				in % of surface of sapwood-section investigated i % av undersökt splintsnittyta				
					Intensity styrka			Total S:a	Intensity styrka			Total S:a	1924 on the 24/10 1924 den 24/10	1925 on the 15/9 1925 den 15/9
		I	II	III	1	2	3		1	2	3			
15/6	1	b 67	b 67	b 67										
	2		b 33	b 33										
	3				67	22		89	1	1		2	(4)	111
1/7	1	br 67	br 100	br 100										
	2													
	3				89			89	12			12	0	89
15/7	1	b 33	b 100	b 33										
	2													
	3				55			55	0,5			0,5	0	55
15/8	1	br 67	b 100	br 100										
	2													
	3				89			89	3			3	0	89
1/9	1													
	2													
	3							0				0	0	0
15/9	1		b 33											
	2													
	3				11			11	0,1			0,1	0	11
1/10	1													
	2													
	3							0				0	0	0
15/10	1													
	2													
	3							0				0	0	0
1/11	1													
	2													
	3							0				0	0	0
15/11	1													
	2													
	3							0				0	0	0

Table 48. **Investigation into damage to stored round timber.**
Summary of amount and intensity of damage on the 15th September, 1925.

Undersökning av skador på lagrat rundvirke.
Sammanfattning av skadornas omfattning och styrka den 5. 9. 1925.

Kind of wood: Pine. Trädslag: Tall. Treatment: Stripe-wise stripped. Behandling: Randbarkat. Method of stacking: In a triangle. Upplägning: I triangel

Date of felling in the year 1924 Avverkning år 1924 den	Intensity of damage Skadans styrka	Attack in % of number of sections investigated in section Angrepp i % av antal undersökta snitt vid sektion			Total amount of damage Summa skada								Comparative figures for damage in the year Jämförelsetal för skådan år	
					in % of sections investigated i % av undersdkta snitt				in % of surface of sapwood section investigated i % av undersökt splintsnittyta					
					Intensity styrka			Total S:a	Intensity styrka			Total S:a	1924 on the 24/10 1924 den 24/10	1925 on the 15/9 1925 den 15/9
		I	II	III	1	2	3		1	2	3			
15/6	1	br 33												
	2	br 67	br 67	br 67										
	3		br 33	br 33	11	67	22	100	11	52	20	83	150	211
1/7	1													
	2													
	3	br 100	br 100	br 100			100	100			100	100	110	300
15/7	1													
	2													
	3	br 100	br 100	br 100			100	100			100	100	80	300
1/8	1													
	2													
	3	br 100	br 100	br 100			100	100			100	100	20	300
15/8	1													
	2	br 33												
	3	br 67	br 100	br 100		11	89	100		11	89	100	90	289
1/9	1													
	2													
	3	br 100	br 100	br 100			100	100			100	100	0	300
15/9	1													
	2													
	3	br 100	br 100	br 100			100	100			85	85	0	300
1/10	1													
	2	br 33	br 33	br 33										
	3	br 33	br 67	br 67		33	56	89		30	55	85	0	234
15/10	1													
	2	br 33	br 17	br 50										
	3	br 67	br 83	br 50		33	67	100		28	61	89	0	267
1/11	1		b 16											
	2	br 17	b 17											
	3	br 83	br 67	br 100	5	11	84	100	1	7	67	75	0	279
15/11	1													
	2	b 17		br 33										
	3	br 83	br 100	br 67		16	84	100		7	82	89	0	284

Table 49. **Investigation into damage to stored round timber.**

Summary of amount and intensity of damage on the 15th September, 1925.

Undersökning av skador på lagrat rundvirke.

Sammanfattning av skadornas omfattning och styrka den 15. 9. 1925.

Kind of wood: Spruce. Treatment: Stripe-wise stripped. Method of stacking: In a triangle.

Trädslag: Gran. Behandling: Randbarkat. Uppläggningssätt: I triangel.

Date of felling in the year 1924 Avverkning år 1924 den	Intensity of damage Skadans styrka	Attack in % of number of sections investigated in section Angrepp i % av antal undersökta snitt vid sektion			Total amount of damage Summa skada								Comparative figures for damage in the year Jämförelsetal för skadan år	
					in % of sections investigated i % av undersökta snitt				in % of surface of sapwood section investigated i % av undersökt splintsnittyta					
					Intensity styrka			Total S:a	Intensity styrka			Total S:a	1924 on the 24/10 1924 den 14/10	1925 on the 15/9 1925 den 15/9
		I	II	III	1	2	3		1	2	3			
15/6	1	r 33												
	2			r 33										
	3	r 67	br 67	r 67	11	11	67	89	1	8	54	63	0	234
1/7	1													
	2	r 33												
	3	br 67	br 100	br 100		11	89	100		11	82	93	30	289
15/7	1													
	2			br 33										
	3	br 100	br 100	br 67		11	89	100		11	89	100	30	289
1/8	1	r 33	r 33	r 33										
	2	r 33		br 34										
	3	r 34	br 67	r 33	33	22	45	100	16	11	25	52	0	212
15/8	1													
	2	br 100		br 67										
	3		br 100	br 33		56	44	100		48	41	89	0	244
1/9	1													
	2	r 33												
	3	br 33	br 33	br 33		11	33	44		1	33	34	0	121
15/9	1		br 33	br 33										
	2	br 33	br 34	br 33										
	3	br 67	br 33	br 34	22	33	45	100	13	8	32	53	0	223
1/10	1													
	2	br 67	br 100	br 33										
	3	br 33		br 67		67	33	100		4	7	11	0	233
15/10	1	r 17		br 17										
	2	r 17	r 17	r 17										
	3	b 17	b 17	b 17	11	17	17	45	11	7	4	22	0	96
1/11	1													
	2	r 17												
	3		r 17	r 17		6	11	17		1	3	4	0	45
15/11	1													
	2	r 33	r 17	r 33										
	3	r 17	r 33	r 17		28	22	50		18	22	40	0	122

stripped to suffer severe damage chiefly by rot, but also by some blueing. These kinds of damage appear to culminate in timber felled during July to August.

The damage occasioned by rot exercises a considerable lowering influence upon the value of the timber as pulp-wood for sulphite cellulose, for which purpose it has become largely useless, at any rate as first-class such.

The wholly decorticated spruce, on being kept over, has, on the other hand, suffered very little damage, chiefly slight blueing in cracks, and this damage seems greatest on the spruce felled earliest in 1924. It is worth mentioning that the wholly decorticated spruce felled on the 1st September or later in 1924, on investigation in 1925 was on the whole as yet practically free from storage-damage. The damage caused to the wholly decorticated spruce, kept over till next year, can, however, by reason of its slight extent in no instance exercise any really depreciating effect upon the usefulness of the wood even as sulphite wood.

Summary of the practical results of storing pulp-wood.

The feeblest forms of both blueing and storage-rot play a very insignificant part, or none, in the practical use of the timber for the production of wood-pulp.

The medium or most intense form of blueing, on the other hand, makes the use of the wood impossible for best quality sulphite cellulose and white mechanical pulp, but plays, on the other hand, a more subordinate part in the sulphate industry, at any rate when it is a question of turning out kraft-pulp.

The two severer forms of storage-rot produce, however, in the manufacture of sulphite cellulose and white mechanical pulp a serious reduction to quality through discoloration, for which reason wood damaged in such a way becomes useless both for prime sulphite cellulose and white mechanical pulp. Furthermore, storage-rot in its more pronounced forms exercises in all wood-pulp manufacture a depreciative effect upon the value of the wood, some of the solid substance of the wood being disintegrated — and the dry volume-weight being reduced — so that the consumption of wood for each weight-unit of pulp is augmented. In the same way storage-rot exercises a very depreciative effect upon the strength of the wood, which, on the other hand, is probably less the case with blueing.

On account of these conditions we must look upon storage-rot as a much more serious kind of demage than blueing, and as of two evils

one chooses the lesser, it is natural that one takes blueing rather than rot, where both cannot be avoided.

The experiences gained by our storage-tests here related may be summarised into the following general advice concerning the most appropriate method of treating such timber (in the first instance pulpwood) as it is desired to dry by storing before removing it from the forest or making use of it.

1. Treament: Timber should always be decorticated, as intact timber dries very slowly and is seriously damaged by rot before doing so.

Stripe-wise stripped should only be resorted to in exceptional cases, although it is much cheaper than wholly decortication, inasmuch as timber which is stored for any lenght of time with adhering stripes of bark is severely attacked by storage-rot and, furthermore, in no small degree by blueing.

The circumstances which may speak in favour of stripe-wise stripping are: if the wood prior to storage proper, or storage for the purpose of drying, is floated for any distance, as the adherent stripes of bark loosen and drop off before storage, or if the timber is of very small dimensions which are exposed to conditions favourable for drying.

For the rest whole decortication should always be resorted to, which leads not only to the most rapid and efficient drying throughout but also to the least amount of damage. Blueing may certainly, as has been pointed out above, in the case of entire decortication become more intense than with other methods of treatment, but by way of compensation one gets rid of storage-rot.

2. Storage or stacking. The airier the wood can be stored and the more elevated above the ground, the better. Triangular stacks when storing in the forest and loosely packed stacks on proper dunnage in airy places, where special stacking spots are used, cause the least damage in drying.

3. Time of felling. Spruce. — When storing in the forest the best drying-result is obtained, with the least storage-damage, if the spruce is felled after the 1st September, in the autumn or during the winter, and then kept over during the ensuing summer, to be carted out the following winter. If spruce is wholly decorticated and put up in airy stacks, it appears otherwise possible to fell it at any time whatsoever without any very great detriment — except at the height of summer, when blueing occurs also easily in spruce.

Pine. — It is impossible to bring about any very complete drying of pine in the forest without storage-damage, inasmuch as blueing always makes its appearance parallel with the drying of the timber. If better

drying is desired, the damage will nevertheless be less, and be restricted mainly to blueing if the timber is felled in winter or spring, wholly decorticated and put up in airy triangular stacks. If felling takes place in the autumn, and the timber is allowed to dry in the forest during the next summer, the damage, on the other hand, will be greater. If one wishes to guard pine-timber more against storage-rot, this must be done by making a concession to the demand for drying. If the pine is thus felled in the autumn, shortly after the 1st September,[1] wholly decorticated and stored in airy triangles, fairly good evaporation is reached before winter, without damage, and this evaporation may frequently be quite sufficient for, let us say, making the timber floatable.

If the timber is to be floated, a fair amount of evaporation, without any detriment, may also take place before floating by stacking the timber in an airy place close to the water-way. And if the floating-conditions are such that the timber can be put in the water later on in the spring, independent of the spring-floods, or in the beginning of summer — yet always before mid-summer — the timber may reach relatively fair evaporation also in direct winter-felling, without any appreciable storage-damage, which does not make its appearence until some time in the latter part of summer.

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[1] This period which in our tests in the Bergslagen District or at Garpenberg has proved to be the one where the blueing and storage-rot fungi cease for the year, naturally only holds good for districts with a similar climate.

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Explanation of Plates I and II.

Development of the isolated blueing fungi in winter-felled pine and spruce (Test-Series X, f. p. 604). The wood sectors were inoculated on the tangential surface and the fungi allowed to grow for 25 days. Direct photographic reproduction of the discoloured sectors in natural size.

RESUMÉ.

Biologiska och praktiska undersökningar över blåyta hos tall och gran.

De nu publicerade undersökningarna påbörjades år 1923. Enligt planen skulle å ena sidan utföras en rent vetenskaplig undersökning över blåytans natur och ekologiska förutsättningar och å andra sidan anställas praktiska försök i syfte att utröna de lämpligaste metoderna att lagra rundtimmer till förekommande av blåyteskador.

Det var ursprungligen vår avsikt att begränsa studiet av blåytesvamparna så tillvida, att renkulturer skulle göras endast i anslutning till de praktiska försöken. Då emellertid isoleringsresultaten redan från början gingo i en högst intressant och oväntad riktning — de syntes nämligen visa, att hyphomyceter och pyknidsvampar spela en större roll såsom blånadssvampar än ascomyceter — blev det nödvändigt att göra en mera allsidig utredning över blåytesvamparnas natur. Isoleringsförsök utfördes därför med virke från skilda delar av Sverige. Härvid undersöktes såväl stående träd som timmer och sågat, i brädgårdar lagrat virke.

Svamparnas isolering och renodling liksom den experimentella undersökningen av deras biologi ha utförts av MELIN. Den morfologiska och systematiska bearbetningan av svamparna har gjorts huvudsakligen av LAGERBERG. Resultaten av dessa undersökningar framläggas i del I.

Kulturförsöken ha gjorts på Skogshögskolans mykologiska laboratorium.

De praktiska försöken anlades på Garpenbergs kronopark i Kopparbergs län, varest Domänverket frikostigt tillhandahållit allt undersökningsmaterial och pågingo under 1923—1924. Resultaten av dessa, som bearbetats av LUNDBERG, meddelas i del II.

Ehuru de praktiska försöken ytterst åsyftat ett studium av olika lagringsformers inverkan på blåytans uppträdande, ha samtidigt även andra skador, framför allt rötskador och sprickbildning, studerats. Därjämte har i detta samband även uttorkningsförloppet, särskilt i under sommarhalvåret avverkat virke, varit föremål för ett ingående studium. Vi ha funnit lämpligt att framlägga resultaten även av dessa undersökningar i del II.

Vid de praktiska försökens genomförande ha vi haft en synnerligen värdefull hjälp av överassistenten jägmästare MARTIN ENANDER, Garpenberg. Vi tacka honom förbindligast härför.

Herr ENANDER har därjämte under åren 1924—1925 på eget initiativ utfört en del kompletterande undersökningar rörande olika lagringsformers inverkan på blåytans utveckling och andra skadegörelser i rundvirke. De av honom därvid erhållna resultaten ha välvilligt ställts till vårt förfogande och komma delvis att åberopas i del II.

Av de i del I ingående figurerna — samtliga original — äro teckningarna, som utförts av LAGERBERG, framställda med tillhjälp av Abbe's teckningsapparat och förminskade vid reproduktionen.

Våra undersökningar ha möjliggjorts genom understöd från »Fonden för skogsvetenskaplig forskning», för vilket vi härmed framföra vårt vördsamma tack.

Skogshögskolan, Stockholm i mars 1927. *Författarna.*

I. BLÅYTESVAMPARNA OCH DERAS BIOLOGI.

1. Tidigare uppgifter om orsak till blåyta.

Den förste, som ställer blåytan i samband med svampangrepp, synes vara R. Hartig (1878, sid. 66). Vid sina undersökningar över sårröta hos träd hade han anledning att yttra sig om en av Willkomm (1866) närmare beskriven svampform, »*Xenodochus ligniperda*», som denne författare ansåg vara upphovet till s. k. »Rotfäule» hos tall och gran. Hartig framkastar en förmodan, att den i själva verket hörde samman med »*Ceratostoma pilifera (Sphæria dryina),*» vilken han betecknar som orsak till barrvirkets blånad.

År 1878 hade Saccardo (sid. 370) grundat släktet *Ceratostomella* för sådana *Ceratostoma*-arter, som ägde ofärgade sporer; i detta nya släkte inordnades den gamla arten *piliferum* av Winter (1887).

Den första mera ingående undersökningen över blåyteskador publicerades några år senare i Nordamerika av von Schrenk (1903). De hade iakttagits på virke av *Pinus ponderosa,* och den ansvariga svampen, som kallas *Ceratostomella pilifera,* erhåller samtidigt en ganska utförlig behandling.

Det skulle emellertid snart visa sig, att blåytans etiologi tarvade en betydligt grundligare utredning. Till en början kan då erinras om, att *Ceratostoma piliferum,* som beskrevs av Elias Fries år 1822, i senare mykologers systematiska arbeten blivit behandlad som en icke enhetlig art. Redan Fuckel (1869—70) urskiljer sålunda icke mindre än 4 former, vilka i oförändrat skick ingå i den beskrivning av *Ceratostomella pilifera,* som Winter lämnat i Rabenhorsts kryptogamflora (1887) ehuru med det tillägget, att under dem möjligen kunna dölja sig lika många arter.

Vad *Ceratostomella pilifera* i själva verket betydde, klarlades först år 1907 genom Münch, som visade att detta namn var en beteckning för en ganska heterogen blandning.

Münch isolerade och undersökte i detalj icke mindre än 4 av honom namngivna *Ceratostomella*-arter: *C. Pini, C. Piceæ, C. cana* och *C. cærulea.* Av dessa var den förstnämnda genom peritheciernas litenhet väl karakteriserad, de övriga, som sammanfördes till en s. k. *pilifera*-grupp, igenkändes bäst på sina åtföljande konidiestadier.

På en femte art med perithecier av *Ceratostomella*-typ grundade Münch det nya släktet *Endoconidiophora;* arten kallades *E. cærulescens.* Anledningen till denna särställning var det egendomliga konidiestadiet, som visades vara identiskt med den tidigare beskrivna, till dematiaceerna hörande *Chalara Ungeri.*

Av övriga svampformer, som växte på blånat virke, studerade Münch endast en *Cladosporium*-form, som han dock icke kunde visa äga betydelse som blåytesvamp. Münch kommer därför till den slutliga uppfattningen, att *Ceratostomella*-släktet och det närstående släktet *Endoconidiophora* inrymma blåytesvamparna par préférence.

Samtidigt med Münchs studier över blåytan i Tyskland var denna fråga även i Nordamerika föremål för mykologers intresse. Här hade Hedgcock redan 1906 framlagt resultatet av sina ganska omfattande undersökningar över den Nya Världens blåytesvampar. Hedgcock bibehåller namnet *pilifera* för en art, som visat sig äga en vidsträckt spridning över Staterna på virke av ett flertal *Pinus*-arter, och han betecknar densamma som den viktigaste blåytesvampen. Dessutom behandlas *Ceratostomella echinella* Ellis et Everhart

och beskrivas som nya icke mindre än 6 arter, nämligen *C. Schrenkiana, C. capillifera, C. pluriannulata, C. minor, C. exigua* och *C. moniliformis*.

Några nordamerikanska blåytesvampars biologi har senare varit föremål för undersökning av Miss Rumbold (1911). Man finner av hennes framställning, att *Endoconidiophora*-typen även är företrädd i Amerika.

Även om det för närvarande icke låter sig överblickas, i vilken utsträckning de vedblånande *Ceratostomella*-arterna äro gemensamma för Gamla och Nya Världen, bör man kunna förutsätta, att åtminstone en del av dem är detta. Ett par sådana arter som *C. Pini* och *C. cærulea* torde säkerligen vara spridda över hela den norra barrskogsgördeln. Enligt Hubert (1921, sid. 220) skall den förstnämnda finnas även i Nordamerika. Det synes oss icke uteslutet, att de av Hedgcock uppställda arterna *capillifera, pilifera* och *Schrenkiana* vid förnyad undersökning skall låta sig förenas med *Ceratostomella cærulea*. Hans art *pluriannulata* däremot, som visat sig tillhöra den svenska svampfloran, är välgrundad; troligtvis finns den även i andra europeiska länder.

Övriga av Hedgcock närmare studerade blånadssvampar äro alla hyphomyceter: 7 arter av släktet *Graphium*, av vilka 2 beskrivas som nya, 2 *Hormodendrum*-arter, därav 1 ny, samt ett mycel, vilket hänföres till släktet *Hormiscium* och beskrives som *H. gelatinosum*.

Det kan slutligen tilläggas, att även *Lasiosphæria pezizula* (B. et C.) Sacc. kan framkalla blånad (jfr Hubert 1921, sid. 214).

Den ovan lämnade sammanställningen ger kanske det intrycket, att blåytesvamparna åtminstone i huvudsak blivit väl utforskade. Detta är emellertid visst icke händelsen. Våra undersökningar ha visat, att man såväl bland sphæropsiderna som framför allt bland hyphomyceterna träffar former, vilka som blånadssvampar äro lika aktiva som någonsin *Ceratostomella*-arterna, ja mången gång till och med överträffa dessa. Flera av dem äro därtill uppenbarligen mycket allmänt spridda.

Som substrat — såväl vid våra isoleringar som vid de senare kulturerna — ha vi använt maltagar (5 % maltextrakt, 1,5 % agar). Vid isoleringarna har först en råkultur anlagts därigenom, att mycket små stycken missfärgad ved överförts på plattor. Från dessa råkulturer ha sedermera renkulturer erhållits genom det inom bakteriologien vanliga spridningsförfarandet, varvid sålunda råkulturernas sporer eller konidier bildat utgångsmaterialet. Från de framställda renkulturerna ha sporer eller konidier återigen överförts på tangentialytan av partiellt steriliserade sektorer ur trissor av tall- och granved (jfr tavl. I och II).

2. Missfärgningens art och orsak.

Som bekant betecknas i praktiken sedan gammalt allt genom svampar mörkfärgat virke, vilket icke är rötskadat, som blånat. Även färger utan ett spår av blått komma härvid i fråga. Virkets vattenhalt inverkar f. ö. såväl på färgens kvalitet som på dess mättningsgrad, vartill kommer, att blånadsfärgens art även står i direkt samband med svampens. Münch (1908, sid. 305) har gjort den intressanta iakttagelsen, att mycelfärgen hos en och samma svamp växlar med det substrat, på vilken svampen odlades. Även vi ha gjort samma erfarenhet (jfr tab. 14). Detta gällde icke blott färgens styrka, utan även dess nyans. Münch anser sålunda, ett färgen endast med för-

siktighet får användas som en artkaraktär. I detta uttalande kan man instämma, i all synnerhet som det ofta inträffar, att flera olika mycel växa tillsammans i samma vedstycke.

Även om nu den s. k. blånaden mycket ofta saknar varje blå anstrykning, förekomma dock fall, då en blåaktig skiftning är fullt tydlig. Härtill har MÜNCH (1907, sid. 533) givit en säkerligen riktig förklaring. Den blåa skiftningen är ett rent optiskt fenomen och beror av det sätt, på vilket svamphyferna förekomma fördelade i virket. Om en mörkfärgad kropp, fint fördelad, är upptagen i ett genomskinligt medium, förlorar den sin egenfärg och erhåller en annan, vars art är beroende av partiklarnas storlek. MÜNCH hänvisar till den blåa färg, som är utmärkande för utspädd mjölk, för förtunnad cigarrettrök och för himmelens blå, som framkallas av ytterst små kroppar, vilka hållas svävande i det i och för sig färglösa lufthavet. De blåaktiga skiftningar, som framträda, då en gulvit splintved genomdrages av fina, mörkbruna hyfer, kunna otvivelaktigt förklaras på liknande sätt. När hyferna i detta nå en sådan massutveckling, att märgstrålar och hartsgångar äro helt och hållet utfyllda och på det radiära längdsnittet framträda som fina tuschstreck, är den blåa tonen försvunnen, och färgskalan går då mera i grå- eller brunsvart.

Innan färgfrågan lämnas, förtjänar framhållas, att i vissa fall även en tydlig mörkfärgning av vedcellernas membraner kan konstateras, och att svampen otvivelaktigt är orsak till densamma.

3. Blånadens uppträdande i det fria och svamparnas spridningsmöjligheter.

I praktiken urskiljas stundom två olika slag av blånad: stockblånad och ytblånad. Den förra utbildas i timmer, som icke utdrivits omedelbart efter avverkningen eller i stammar, som dött på rot, och medför i allmänhet större förlust, då splintmassan i sin helhet kan bli missfärgad på ganska kort tid. Ytblånaden uppkommer mest i brädgårdar på det sågade virket och når i gynnsammare fall icke vidare på djupet, varför den med tjänliga medel kan avlägsnas. Den föreställningen är icke ovanlig, att tvenne till arten skilda former av skadegörelse här skulle föreligga eller med andra ord, att olika svampar skulle vara verksamma i de olika fallen. Även om detta understundom kan vara händelsen, torde dock skadornas växlande omfattning i främsta rummet framkomma som en följd av olika förutsättningar för svamparnas kvantitativa utveckling.

Som blåytan i allmänhet uppträder i naturen, ger den kanske närmast intryck av att vara resultatet av saprofytiska svampformers verksamhet i ett dött substrat, och i de flesta fall är den kanske också detta. Under sådana förhållanden är det av vikt, att MÜNCH (1908, sid. 32) kunnat fastställa, att mycelen även kunna inträngа i levande ved och döda dennas parenkymceller. Förutsättningen härför visade MÜNCH vara en viss minskning av vattenhalten och samtidigt härmed en ökning av den inre luftvolymen.

I England har denna fråga varit föremål för undersökningar av WILSON (1922, sid. 88).

I naturen uppkomma säkerligen ganska ofta, exempelvis genom vindbrott, skador på trädens rotsystem, som kunna medföra en nedsättning i stammarnas vattenhalt och få en blånad till följd. Även en annan art av skadegörelse torde

vara av icke ringa betydelse härutinnan, nämligen angrepp av barkborrar. I Nordamerika har VON SCHRENK (anf. arb.) sålunda kunnat leda i bevis, att *Dendroctonus ponderosæ* var den indirekta orsaken till blånadsskador på *Pinus ponderosa*. Från England föreligger därtill en uppgift (MAC CALLUM, 1922, sid. 232) om angrepp på stående tallar av *Ceratostomella Piceæ* och *C. Pini*, och i samtliga fall var barken genomsatt av den större märgborrens (*Blastophagus piniperda*) gångsystem.

Som ytterligare exempel på yttre skadors betydelse för uppkomsten av blåyta i levande träd kan här förelöpande framhållas, att *Endoconidiophora cærulescens* visat sig med lätthet kunna inträngа i stämplade granar, som lämnats att kvarstå några år efter stämplingen. Samma möjligheter föreligga även för en annan svamp, *Discula pinicola*, varom lämnas mera detaljerade upplysningar i det följande.

Iakttagelsen, att blåyta lätt uppstår i samband med barkborrskador har uppväckt den tanken, att dessa insekter skulle vara direkta smittospridare. För *Ceratostomella*-arternas sporer utgöra de också troligen det viktigaste spridningsmedlet. Vid mognaden ligga dessa inbäddade i ett slem, som ej löses i vatten, och utpressas med detta genom peritheciemynningen, där de anrikas som en bollformig massa. Denna flyter så småningom ned utefter peritheciehalsen (jfr fig. 24 *a*). En spridning av sporerna torde därför endast kunna ske genom deras vidhäftning på ett berörande föremål. FALCK (1916) tycks räkna med den möjligheten, att spridningen även skulle kunna ske på endozoisk väg, men detta synes oss föga antagligt. För *Ceratostomella*-konidierna anser han flytande vatten vara det viktigaste spridningsmedlet, närmast på grund av den lätthet, med vilken en samling konidier upplöses och fördelas vid tillförande av vatten. Detta kan ju ha sin riktighet, men när han sedermera även gör det påståendet, att inga fruktkroppsformer hos blåytesvamparna sprida sina sporer med tillhjälp av vinden, gör han sig tydligen skyldig till ett förbiseende. Kunde man ej räkna med vindspridning, bleve det ganska svårt att förstå den snabbhet, med vilken blåyta utvecklas överallt, där omständigheterna äro gynnsamma härför. Även torde man få antaga, att stockarna ha möjligheter att direkt angripas av mycel från marken, där detsamma i så fall måste finnas växande. Vid tät virkeslagring kunna säkerligen blånadssvampar växa direkt över från en stock till en annan genom kontaktytorna. I brädstaplar inträffar exempelvis ej sällan, att den solida vedpelare, som genom virkets korsläggning uppkommer i staplarnas hörn, nedifrån och allt upp igenom tar stark blånad (»ströblånad»), medan plankorna i övrigt äro oskadda.

4. De svenska blåytesvamparna.

A. Arter av fam. Ceratostomataceae.

Ceratostomella-arternas perithecier anläggas i regel helt ytligt. De äro för blotta ögat kolsvarta, i mikroskopet svartbruna; deras konsistens är spröd. Halsen uppbygges av ett enda lager, parallella, långcelliga hyfer, som under utväxandet äro kupolformigt sammanslutna (jfr fig. 10 och 15) och ofärgade i toppen. Vid peritheciemognaden lösgöras de här från varandra som en krans utböjda cilier, på vilka den utträdande spormassan temporärt uppfångas. Hos samtliga av oss undersökta arter utmärkes peritheciebuken av

en mer eller mindre rik behåring. Dess innehåll är mycket svårtillgängligt för iakttagelser. Som omogen innehåller den stora mängder fett, vilket lätt utträder, om fruktkroppen pressas sönder under täckglaset. Sporsäckarna äro ytterst små och låta sig ej närmare undersökas, då de äro färdiga av den anledningen, att deras membran starkt förslemmas och sönderfaller, så snart den kommer i beröring med vatten. Å omogna perithecier kan man dock konstatera, att sporsäckarnas form är klotrund eller något päronlik. Sporantalet torde i regel vara 8. Sporernas form är apelsinklyftlik.

Den stora yttre likhet, som perithecierna av skilda arter uppvisa, gör det vanskligt att enbart med ledning av dem utföra en korrekt artbestämning. Ett dylikt försök har emellertid gjorts av Hedgcock, som därvid i främsta rummet tar sikte på den terminala ciliekransens utformning. Münch (1907, sid. 540) anser dock, att de av honom uppställda arterna icke äga några systematiskt brukbara karaktärer i sina cilier. Vi ha med anledning härav ägnat denna fråga särskild uppmärksamhet, och ha kommit till den uppfattningen, att Hedgcock beträffande ciliernas systematiska betydelse varit inne på rätt väg. Till och med arterna inom den av Münch urskilda »*pilifera*-gruppen» äga i sina cilier goda karaktärer. Vid en kommande revision av *Ceratostomella*-släktet är det därför ofrånkomligt, att cilierna vederbörligen beaktas.

Över den formväxling, som *Ceratostomella*-arternas konidiestadier uppvisa, har Münch (1907, sid. 538) lämnat en mycket översiktlig framställning. Han urskiljer följande typer: 1) *Cladosporium*-typen (jfr fig. 16 *d*); 2) en typ med konidier i terminala, huvudlika gyttringar — av Hedgcock betecknad som *Cephalosporium*-typen (jfr fig. 11 *a*); 3) konidieax-typen, som närmast ansluter sig till släktet *Sporotrichum* (jfr fig. 5 *c*). *Cladosporium*-typen varieras i sin helhet ganska mycket, och är genom övergångar tydligt förbunden med *Cephalosporium*-typen. Den sistnämnda glider i sin tur utan språng över i ax-typen. Såsom ytterligare form för konidiebildning anför Münch den knoppning, i vilken de ursprungligen bildade konidierna kunna inträda. Såsom ett särskilt intressant resultat av hans studier över blånadssvamparna måste man beteckna upptäckten, att stilbacésläktet *Graphium* även lämnade bidrag till *Ceratostomella*-släktets konidiestadier. För *C. Piceæ* utgör nämligen förekomsten av ett grafium (jämte mycelkonidier av *Cephalosporium*-typ) det viktigaste kännetecknet gent emot den närstående *C. cærulea*. Uppgiftens riktighet har sedermera bestyrkts av Mac Callum (anf. arb., sid. 233—234) och även av oss.

I Hedgcocks arbete över de vedblånade svamparna intar som nämnt *Graphium*-släktet en ganska framskjuten plats. Hans framställning visar, att han var mycket nära att uppdaga sambandet mellan detta släkte och *Graphium*. Orsaken till att så icke skedde kan möjligen ha varit den, att de frågan avgörande perithecierna understundom kunna utebli i kulturerna. En sådan erfarenhet har gjorts på flera händer beträffande *Ceratostomella Piceæ*, och fallet behöver ju icke vara enastående.

Ceratostomella cærulea Münch.

Förteckning över de lokaler, från vilka denna art tagits i renkultur, återfinnes å sid. 163.

På maltagar utvecklar svampen ett tätt, ljusgrått luftmycel. Det bildar ett virrvarr av hyfsträngar, vilka kanske bäst kunna förliknas med ett taggtråds-

nät. Strängarna äro vitmjöliga av konidier (fig. 1). Koloniernas undersida är svartgrön, deras tillväxtsiffra[1] 3,5, utvecklingen är regelbundet centrifugal (fig. 2), lukten tydligt förnimbar, syrlig. Svampen utvecklar sig kraftigare på tall än på gran. Ett perithicium återges i fig. 3. Bukmåttens växlingar: höjd 144—240 μ, bredd vid ekvatorn 160—280 μ. Halslängden är i medeltal 1 mm och når på större fruktkroppar 1,5 mm.

Ciliernas antal är i medeltal 24, deras tjocklek vid basen är 2 μ och under den rundtrubbade toppen 1,6 μ. Längderna äro underkastade ganska stora växlingar även inom en och samma ciliekrans — de erhållna måtten falla mellan 100 och 35,7 μ. Sporer 3,7—4,7 × 1,5—1,9 μ.

Perithecier med flera halsar träffas ej så sällan. Det kan framhållas, att FUCKEL (anf. arb., sid. 129, tavl. IV, fig. 41) har som ny art (*Ceratostoma multirostratum*) beskrivit en form, hos vilken vid sidan av enhalsade perithecier även förekommo sådana, som ägde 2—6 divergerande halsar. Kanske har denna nya art grundats på en liknande tillfällig avvikelse som den vi ha observerat.

En annan anmärkningsvärd avvikelse yttrar sig i utbildning av flera ciliekransar. MÜNCH (1907, sid. 564) håller för troligt, att HEDGCOCK grundat sin nya art *pluriannulata* på dylika perithecier. Emellertid är det av flera skäl fullt klart, att *C. pluriannulata* måste betraktas som en från *C. cærulea* väl skild art (jfr sid. 184).

Konidiestadierna av *Cephalosporium*-typ äro de vanligaste; ofta utvecklas de i *Cladosporium*-riktning (fig. 5 *a*). Konidieställningarnas fullständiga fragmentering har till följd, att konidierna, som icke enbart framgå ur grensystemens toppceller, få en ganska växlande storlek (fig. 5 *b*). Längden växlar mellan 5,6 och 11,2 μ och tjockleken mellan 1,9 och 3,7 μ. I kulturer på maltagar inträda de i en livlig knoppning.

Den för *Ceratostomella cærulea* kanske mest karakteristiska konidieställningen är den axlika. Axen genomväxas stundom för att på nytt upprepas (fig. 5 *c*) och någon gång kunna de även vara sparsamt grenade. Deras konidier äro i regel något kortare och inbördes mera jämnstora (fig. 5 *b*, nederst) än de som uppstå i konidieställningar av annat slag.

C. cærulea hör till de mera aktiva blånadssvamparna. I tallvirke framkallar den en mycket kraftig, nästan blåsvart missfärgning, i granvirke blir densamma svagare och av mindre omfattning (tavl. I). Å ett stycke tallved, i vilket svampen nått maximal utveckling, framträda på det radiära längdsnittet märgstrålarna för blotta ögat som brunsvarta band, och de vertikala hartsgångarna synas markerade som fina tuschstreck. Märgstrålarnas parenkymatiska cellräckor äro mer eller mindre fullständigt utfyllda av tämligen parallellt förlöpande hyfer. Under sin tidigare utveckling kunna de bilda bollformade härvor i parenkymcellerna, och det ser ut som om dessas kärnor utgjorde attraktionscentra för hyfsamlingarna (fig. 6). Cellformen är i ett avseende av intresse. Här och var förekomma nämligen celler, som äro klubblikt ansvällda mot den ända, som pekar i hyfens tillväxtriktning. Samma celltyp utbildas även hos andra arter av *Ceratostomella*-släktet (jfr fig. 11 *f*), och den har också observerats av HEDGCOCK.

Hos tallen påverkas märgstrålarnas parenkymceller på ett ganska anmärkningsvärt sätt av det inkräktande svampmycelet. De kontraheras, så att

[1] Tillväxtsiffran betyder uppmätt radietillväxt i cm under 10 dagar vid + 22° C, i förevarande fall alltså 3,5 cm.

raderna lossna från varandra, och de helt fria cellräckorna visa timglasliknande insnörningar (fig. 7).

I de vertikala hartsgångarnas parenkymskidor liksom i deras hålighet finner man även rikligt med hyfer. Däremot uppträda de relativt sparsamt i de trakeidala cellerna och i trakeiderna och äro här smala (omkring 5 μ). De framtränga längs genom trakeiderna, och växa även utan att i något avseende förändras i periklin riktning genom ringporerna, men de ha också förmåga att direkt genomborra de tjocka trakeidväggarna. Särskilt på de radiära ser man detta överallt. Man får närmast det intrycket, att genombrottet sker på mekanisk väg. Då den fina perforatorn nått igenom, sväller den omedelbart ut i den normala hyfvidden och kan till och med under stundom även överskrida denna (fig. 8).

Ceratostomella-hyfernas förmåga att direkt perforera trakeidväggarna hos barrträden finns redan avhandlad i litteraturen. Särskilt har HUBERT (1921, sid. 218) ägnat denna fråga rätt mycken uppmärksamhet.

Våra försök att infektera granvirke med *Ceratostomella cærulea* ha givit något växlande resultat. Den uppkommande missfärgningen har stundom blivit svag och starkt begränsad (jfr tavl. I), i andra fall har splinten på den ympade klossen genomfärgats till en ganska stor del. Men färgen är svag. Perforationer av de tangentiella väggarna äro vanliga. Det är tydligt, att den svaga blånaden står i samband med en mindre stark färgning av hyferna, och denna i sin tur står säkerligen i samband med de näringsbetingelser, som granvirket kan erbjuda.

Ceratostomella Piceæ MÜNCH.

Denna art har isolerats i renkultur från 10 olika lokaler (jfr sid. 174.)

Den uppträder i naturen mycket ofta i intim blandning med *C. cærulea* men är som blånadssvamp av underordnad betydelse. Detta bestyrkes såväl genom MÜNCHS undersökningar som genom MAC CALLUMS (anf. arb. sid. 233).

Under sådana förhållanden kan man beteckna det som mindre lyckat att FALCK (1916, sid. 141) vid sin behandling av blåytan i TROSCHLS »Handbuch der Holzkonservierung» som exempel utväljer en svamp, som han anser tillhöra *Ceratostomella Piceæ* Münch eller vara denna åtminstone närstående.

På maltagar bildar *C. Piceæ* ett tätt, ljusgrått luftmycel. Undersidan av kolonierna blir slutligen mörkt olivgrön, och deras lukt erinrar om gammal ost. Tillväxtsiffran är 3 (jfr not sid. 698). Med tiden uppträda rikligt koremieartade strängbildningar i luftmycelet, men dessförinnan ha redan de för arten karakteristiska grafierna utvuxit, de första stundom i koncentriska bälten (fig. 9). Perithecier utebli ofta helt och hållet. Både MÜNCH och MAC CALLUM ha tidigare gjort liknande erfarenheter. I våra försök ha de utvuxit endast på starkt surt substrat (0,05 % mjölksyra).

På virke bildar svampen ett tämligen tätt, ljusgrått luftmycel, från vilket snart grafier i mängd anläggas. Perithecier däremot ha icke utvecklats till full mognad ännu efter en tid av 3 månader.

De på maltagar utvecklade perithecierna visade klotrunda bukdelar med en diameter växlande mellan 192 och 224 μ. Även halslängden växlar avsevärt, mellan 1,06 och 1,97 mm, medeltalet ligger vid 1,5 mm. Jämförelsevis ofta förekomma perithecier med flera halsar (jfr fig. 10 *a*).

Det säkraste kännetecknet för särskiljandet av perithecierna hos *C. cærulea* och *C. Piceæ* erbjuda cilierna. Hos den sistnämnda arten äro dessa mycket kortare och inbördes i samma krans ungefär lika långa. Variationen i längd faller mellan 10,7 och 21,4 μ. Vid basen hålla de 3,2 μ och under den avrundade toppen 2,4 μ i tjocklek. Antalet i kransarna växlar enligt våra räkningar mellan 16 och 24, medeltalet torde ligga vid omkring 20.

Sporerna (fig. 10 *c*) äro av samma storleksordning som hos *C. cærulea*, enligt gjorda mätningar 2,3—4,6 × 1,6 μ.

Den direkt på luftmycelet förekommande konidiebildningen är synnerligen ymnig och oftast av *Cephalosporium*-typ (fig. 11 *a*). Konidieaxen synas vara mycket sällsynta hos *C. Piceæ;* för egen del ha vi endast vid ett enda tillfälle sett en antydan till dylika. Knoppning direkt från substrathyferna är icke ovanlig (fig. 11 *b*). I agarkulturer förekomma ofta helt submersa konidieställningar (fig. 11 *c*). Mycelkonidierna äro i regel större än de på grafierna utvecklade, enligt våra mätningar 8—12,8 μ × 3,2—4 μ (fig. 11 *d*).

Grafiernas utveckling är mångskiftande. På trä uppträda de många gånger som skenbart fullt självständiga bildningar, då det ytliga mycelet är så sparsamt, att det icke faller i ögonen. Även på maltagar utvecklas de ofta från mycket tunna och glesa mycelnät (fig. 12 *a*). Då grafiebildningen koncentrerar sig till de pisksnärtliknande, mer eller mindre grenade koremierna, utbildas med tiden ganska komplicerade ställningar (fig. 12 *b*) Grafierna äga ett fint, rakt, intill 2 mm långt svart skaft, mot toppen vidgat till en tät, åt sidorna mer eller mindre starkt utbredd, ofärgad borste av hyfer, från vilkas spetsar konidier avsnöras. Samtidigt avskiljes även vatten, vilket i fuktighetsmättad luft kvarstannar på grafietoppen som en klar droppe (fig. 13 *b*). Grafiumkonidierna mäta 3,2—4,8 × 1,6—1,9 μ (fig. 11 *e*) och inträda lätt i knoppning. I naturen bilda konidierna här i regel klibbiga kulor, som vid torr väderlek hårdna och stundom anta en honungsgul färg.

I kulturer äro grafier med äkta förgrening ingalunda sällsynta. Dessa böra icke förväxlas med de av Münch (1907, sid. 550, fig. 8 *b*) m. fl. behandlade, »prolifererande» grafierna. »Grenarna», som i detta fall utgå under i det närmaste rät vinkel från huvudstammen, äro självständiga epifyter på huvudgrafiet och ha sannolikt uppstått från dess egna konidier (fig. 13 *a*).

Hos *Ceratostomella Piceæ* förekomma också verkliga miniatyrgrafier av en mycket förenklad typ. De ha redan tidigare beskrivits av Münch (1907, sid. 549, fig. 7), och erinra f. ö. delvis om den senare behandlade *Leptographium Lundbergii,* vilken dock är en fullt självständig, ehuru hittills förbisedd art.

I virke växer *Ceratostomella Piceæ* på ungefär samma sätt som *C. cærulea*. Den viktigaste skillnaden erbjuder dess redan omnämnda, svaga blånande förmåga. Särskilt framträder detta, om vid ympningen av veden användes gamla mycelstammar. I ett av våra ympförsök visade ett stycke tallved efter en tid av 3 veckor en för blotta ögat skönjbar missfärgning, som emellertid var begränsad till de 3 yttersta årsringarna. Längre in i veden blevo hyferna ytterst smala och nästan ofärgade. Vid ett annat ympförsök erhölls på tallvirke en fullt tydlig, ehuru ej vidare kraftig blånad. Beträffande hyfernas växtsätt i veden visar *C. Piceæ* överensstämmelse med *C. cærulea*. Även den långsträckta klubbliknande formen på enskilda hyfceller är här mycket vanlig (fig. 11 *f*).

På granved erhölls i ympförsöken i allmänhet icke någon blånad, trots det att hela splinten efter en tid av 3 veckor kunde vara genomvävd av hyfer. Dessa visade sig då vara fina och ofärgade.

Ceratostomella pluriannulata Hedgcock.

Arten är hittills funnen vid ett enda tillfälle (jfr sid. 184).

För övrigt torde den tidigare vara känd endast från Nordamerika

På maltagar bildar svampen ett kompakt, snövitt luftmycel, och denna färg bibehåller sig även i äldre kulturer, åtminstone i deras övre delar (fig. 14). Härutinnan råder en bestämd olikhet gentemot *C. cærulea*. På undersidan bli kolonierna mörkt olivgröna; någon bestämbar lukt avge de icke. Den vegetativa utvecklingen förlöper långsamt — tillväxtsiffran är blott 2 (jfr not sid. 698) — men den fertila är så mycket snabbare. Redan efter 5 dagar finner man mogna perithecier på maltagar. I kulturer från äldre stammar fördröjes dock peritheciebildningen betydligt liksom även på virke. Både på tall- och granved bildar svampen ett tätt, snövitt luftmycel av ungefär samma styrka.

Perithecierna, redan som unga starkt behårade (fig. 16 *a*), ha en i regel klotrund bukdel, 112—224 μ i diameter. Hos ett betydande antal utbildas på halsen under den terminala ciliekransen ytterligare en eller flera sådana (fig. 15), de senare dock stundom mer eller mindre ofullständiga (jfr här översikten å sid. 185). Enligt vår mening uppkomma de övertaliga ciliekransarna som sidobildningar från halshyferna, och ha aldrig varit ändstycken av sådana, en tolkning för vilken Münch (1907, sid. 564) velat göra sig till talesman.

Antalet cilier i de terminala kransarna är mycket växlande, mellan 21 och 58. Längderna inom samma krans äro dock ganska jämna och nå från 39,3 till 67,8 μ. Cilieformen visar en påtaglig avsmalning mot spetsen — från ett tvärmått vid basen om 3,2 μ till blott 0,8 μ under toppen (fig. 16 *b*), en tillsynes god artkaraktär. Halslängden är i medeltal 1,5 mm, men kan i enstaka fall komma upp till nära 5 mm.

I agarkulturer uppstå ofta verkliga dvärgperithecier med normal sporbildning. Deras bukdel plägar vara något päronformad — enligt en mätning 57,0 × 60,7 μ — och halsen omkring 10 gånger så lång som denna. Ciliernas antal nedgår i dylika fall till 10 à 13.

Sporernas storlek är 4,0—4,4 × 1,5 μ (fig. 16 *c*).

C. pluriannulata bildar konidier enligt *Cladosporium*-typen (fig. 16 *d*). Då konidieställningarna lätt fragmenteras, komma konidiernas form och storlek att uppvisa stora växlingar (fig. 16 *e*).

Ceratostomella pluriannulata besitter en relativt svag blånande förmåga. Efter 3 veckors växt på tallved har mycelet framkallat en grå, något flammig missfärgning (tavl. I), som icke sträcker sig till splinten i dess helhet. Hyferna i virket äro också så gott som ofärgade. Cellerna anlägga ganska ofta den långsträckt klubblika form, som beskrivits hos de två föregående arterna, och perforationer av de tangentiella väggarna förekomma allmänt.

På granvirke framkallade svampen efter en 3 veckors växttid icke någon synbar missfärgning (tavl I). Hyfer funnos dock i denna, ehuru fina och ofärgade, till ett djup av 1,5 cm under ytan.

Ceratostomella Pini MÜNCH.

Denna art har tagits i renkultur från 3 lokaler (jfr sid. 189).

Den är f. ö. i naturen synnerligen allmän på tall, och då den dessutom är en mycket aktiv form, hör den otvivelaktigt till våra viktigaste blånadssvampar.

Svampen växer allmänt i de springformade håligheter, som uppkomma på tallstockarna vid barkens frånlösning, och framträder som ett tunt, sotliknande överdrag. Detta består till sin väsentliga del av små sklerotieartade pelare, omkring 0,5 mm höga, vilka ha till uppgift att lyfta den täckande barken så mycket, att svampen får utrymme att utveckla sina reproduktionsorgan. Liknande bildningar med enahanda funktion förekomma även hos en annan pyrenomycet, *Eutypa hydnoidea* von Höhnel, en hos oss vida spridd, allvarlig parasit på björkar.

Ceratostomella Pini bildar på maltagar icke något egentligt luftmycel. Hyferna växa fram direkt på ytan av substratet eller också submerst i detta. Tillväxtsiffran är 5,5 (jfr not sid. 698). Hyferna mörkna snart, så att koloniernas undersida blir brunaktig. I äldre kulturer sker en intensiv knoppning av konidierna, och svampen erhåller därigenom i ytan en smetig, grötliknande konsistens (fig. 18). I denna massa dölja sig mängder av perithecier och därtill ofta även mörka, sklerotieartade kroppar av oregelbunden form.

I renkultur på virke växer *Ceratostomella Pini* med ett tätt gråaktigt luftmycel, något kraftigare på tall än på gran, och genom detsamma framträder den missfärgade vedytan i en blågrå färgton. Svampen är väl karakteriserad genom sina peritheciers litenhet. Under lup synas de som små kulor (fig. 19 *a*), 67,8—150,0 μ i diam. Halsarna äro i regel kortare än motsvarande bukdiameter.

Den terminala ciliekransen innehåller i medeltal blott 12 omkring 20 μ långa cilier, vilka inbördes äro anmärkningsvärt jämna (fig. 19 *b*). Sporernas (fig. 19 *c*) storlek är 4,0—4,3 × 1,0—1,2 μ.

Den för *Ceratostomella Pini* utmärkande konidiebildningen framgår av fig. 20. Ställningarna bestå av racemöst uppbyggda hyfsystem, burna av en huvudaxel av tämligen grova och korta hyfer. Grenarnas prylformade toppceller bära huvudlika gyttringar av konidier, 4,3—5,6 × 1,5—1,6 μ.

I virke framkallar *Ceratostomella Pini* snabbt en ytterst intensiv blånad. På ett stamtvärsnitt kan dess färg synas nästan svartblå (tavl. I), på ett tangentialsnitt verkar den, om veden är rumstorr, mörkt blygrå. Märgstrålarnas parenkym och de vertikala hartsgångarna äro då fullständigt utfyllda av hyfer och synas för blotta ögat som tuschsvarta streck; hyfernas färg är nästan svartbrun.

Innan cellinnehållet helt förtäres av svampen, blir det starkt brunfärgat. Även parenkymcellernas väggar anta delvis en brun färg liksom här och var trakeidernas pormembraner.

Ibland inträngа hyfgrenar i ringporerna, som därvid kunna utfyllas mer eller mindre fullständigt (fig. 21), eljest går den normala passagen mellan trakeiderna just genom ringporerna. Förmåga att perforera deras väggar med förbigående av ringporerna, vilken utmärker förut behandlade arter, saknas.

På granvirke utvecklar sig *Ceratostomella Pini* anmärkningsvärt kraftigt ehuru svagare än på tall (tavl. I). Missfärgningen blir mera gråaktig. Hyferna bli också mycket smala och delvis ofärgade.

Endoconidiophora cærulescens MÜNCH.

Denna biologiskt mycket intressanta svamp ha vi erhållit från 3 lokaler (jfr. sid. 196); allt tyder även på att den är mycket viktig även ur praktisk synpunkt.

I renkultur trivs svampen påfallande väl både på tall- och granved, men den mest intensiva blånaden erhölls på tall. Av andra erfarenheter att döma torde den dock rättast böra betecknas som en gransvamp. Den isolerades ursprungligen ur levande granstammar från Garpenbergs kronopark i Dalarne, vilka överhållits ej fullt 2 år efter en stämpling; stämpelbläcken hade medgivit svampen inträde. Angående blånadens tillväxtförhållanden hänvisas till översikten å sid. 197.

Den kanske mest tillgängliga karaktär, på vilken denna svamp kan bestämmas, är dess lukt. Den bildar nämligen amylacetat vid kultur på de mest skilda kolkällor (maltos, glykos, dextrin, stärkelse, olja) och uppenbarligen i avsevärda mängder. Samma lukt avges även av ympade träklossar, och den kan röja svampens förekomst även i det fria.

På maltagar bildar svampen i början ett ljusgrått luftmycel, som så småningom blir allt mörkare och slutligen antager en svartbrun färg. Undertill blir det oliv- eller svartgrönt. Strukturen är radiärt trådig (fig. 22) och tillväxten påfallande snabb; tillväxtsiffran är nämligen 10 (jfr not sid. 698).

På virke utbildas ett grågrönt luftmycel, som snart blir nästan svart.

Perithecierna äro av fullständig *Ceratostomella*-typ (fig. 23 *a*, 24 *a*). Bukdelen är svagt päronformad; dess största bredd- och höjdmått äro lika, och växla mellan 168 och 208 μ. Påfallande äro de synnerligen rika och långa bukhåren. Halsarna överskrida endast undantagsvis 1 mm i längd. Cilierna äro i medeltal omkring 10, deras längder växla stundom inom samma krans. Vid basen äro de dubbelt så tjocka som vid spetsen, resp. 3,2 och 1,6 μ. Den största uppmätta längden uppgår till 30 μ.

Sporerna (fig. 23 *c*) likna de behandlade *Ceratostomella*-arternas, men äro betydligt större, 7,4—9,3 × 1,9—2,6 μ.

Konidiebildningen hos *Endoconidiophora cærulescens* sker endast på ett sätt, fullständigt avvikande från vad som förekommer inom *Ceratostomella*-släktet. Från de ytliga substrathyferna utbildas en nästan svart, sammetsartad filt av orta upprätta grenar, ur vilkas öppnade spetsar konidier utskjutas i pärlbandslika kedjor (fig. 24 *b*, fig. 25). Konidiebildningen, som alltså är endogen, har uttömmande skildrats av MÜNCH (1907, sid. 567). Det ifrågavarande konidiestadiet är identiskt med den av SACCARDO beskrivna dematiaceen *Chalara Ungeri*.

Konidierna äro mycket starkt växlande till form och storlek (fig. 24 *c*) exempelvis 5,4—7,1 × 5,4 μ, 21,4 × 6,2 μ, 69,0 × 5,0 μ. De längre typerna synas uppkomma under gynnsammare näringsförhållanden.

I ved växa hyferna gärna längs genom trakeiderna, och svampens karaktär av parenkymsvamp blir därför icke så påtaglig. Härmed sammanhänger ock säkerligen stämplingsblånadens snabba längdtillväxt. I märgstrålarna bli korsningsfältenas pormembraner tydligt brunfärgade. Trakeidernas ringporer synas utöva ett lokaliserande inflytande på de vertikala hyfernas grenbildning. På längre sträckor kunna dessa nämligen avge grenar mitt för varje ringpor, som utfylles utan att genomväxas. Detta kan synas egendomligt, då hyferna för övrigt endast genom ringporerna kunna tränga från en trakeid till en

annan. I vårtrakeiderna utvecklas ofta sidoställda dendritiska grensystem av smala hyfer liksom även i de vertikala hartsgångarnas hålighet (fig. 26). Deras sekretoriska celler äro ofta igenstoppade av hyfer och visa då en brunfärgad membran.

I våra renkulturer på granved genomväxte svampen på en tid av c:a 3 veckor de ympade träklossarna helt och hållet, men missfärgningen var ej vidare kraftig och av en gråaktig nyans. I tall blev utvecklingen betydligt kraftigare och missfärgningen gråsvart (tavl. I).

B. Sphæropsideer.

Sclerophoma entoxylina Lagerberg et Melin n. sp.

Denna tidigare obekanta blånadssvamp ha vi endast erhållit från 2 lokaler (jfr. sid. 204). Sannolikt har den dock en vidsträckt spridning.

På maltagar utvecklas ett till en början vitt, flockigt luftmycel, som så småningom antar en grågrön och slutligen gråbrun färg (fig. 27); på undersidan bli kolonierna svarta. Deras tillväxtsiffra är 4,5 (jfr not sid. 698). Hyfändarna utväxa ofta så som återges av fig. 28 *a*. Äldre mycel har sotbrunt färgade hyfer, som slutligen inklädas i ett tämligen grovkornigt exsudat. Cellerna äro i allmänhet långsträckta, vid tvärväggarna uppkomma insnörningar, och en del celler bli kolvlikt ansvällda vid sin ena ända.

I äldre hyfer är klamydosporbildning ganska vanlig (fig. 28 *b*).

Av vikt för svampens identifiering äro de tidigt uppträdande, tämligen väl avgränsade sklerotierna. De bestå av en pseudoparenkymatisk, bruncellig, några få cellskikt tjock vägg, vilken utan skarp gräns övergår i en kärna av tunnväggiga och hyalina celler. I äldre kulturer ha sklerotierna utvecklats till pyknider, fulla av konidier. Pykniderna ha i det närmaste klotrund form; diametern från 150 till över 300 μ. I det fria ha de icke anträffats.

På mikrotomsnitt kunde visas att konidierna bildas endogent och att de frigöras genom de omgivande cellväggarnas upplösning. I allmänhet torde endast en konidie uppstå inom varje cell, men någon gång syntes två sådana ha bildats.

Pyknid med endogen konidiebildning uppmärksammades för första gången av von Höhnel (1909, sid. 1230 o. följ.). Han visar, att den i själva verket ehuru förbisedd förekom hos åtskilliga tidigare beskrivna pyknidsvampar — *Phoma pithyophila* (Corda) Sacc., *Spæropsis acicola* Lév., *Pycnis pinicola* Zopf, *Sphæropsis pithya* Thümen, *Sphæronema Piceæ* Friedler, *Spæronema pini* (Desm.) Sacc., och han sammanför dem alla till det nya släktet *Sclerophoma*. Vår art har icke kunnat identifieras med någon av de här nämnda formerna, av vilka f. ö. de 3 första av von Höhnel uppfattas som synonymer. Konidierna hos *S. entoxylina* äro ofärgade, encelliga med rundtrubbade ändar, 6—9 × 3 μ, i enstaka fall tvåcelliga (fig. 28 *c*).

På virke utvecklar sig *Sclerophoma entoxylina* mycket kraftigt, särskilt på på tall (jfr. tavl. II). Märgstrålarnas parenkymceller genomdragas sålunda av raka, parallella, intill 15 μ tjocka hyfer (fig. 29) med stora och klotrunda oljedroppar. De trakeidala cellernas hyfer äro smala med långsträckta och hantelformade celler med mer eller mindre klotrunda ändstycken, som var för sig innehålla en stor oljedroppe, eller ock sammansättas hyferna av klotrunda celler. Det är av stort intresse, att svampen icke endast lever på parenkymcellernas plasma och assimilater utan även förtär oförvedade cell-

väggar. Varje spår av märgstrålarnas parenkymceller avlägsnas, och korsningsfältens stora porer bli alltså vidöppna (jfr. fig. 29). Att svampen besitter en cellulosanedbrytande förmåga har framgått av kulturförsök, då kolkällan utgjordes av filtrerpapper.

Hyferna passera i allmänhet från en trakeid till en annan genom ringporerna, men även vid sidan av dessa förekomma perforationer av väggarna, dock alltid ytterligt fina. De uppkommande adpressorierna äro kulformigt ansvällda.

Även i granved framkallar svampen en kraftig missfärgning av mörk, svartgrå, något blåaktig nyans (tavl. II).

Discula pinicola (Naumov) Petrak.

Denna hos oss sannolikt allmänna svamp har blivit identifierad tack vare välvilligt bistånd av den framstående sphæropsidékännaren dr. F. Petrak.

Dr. Petrak har fäst vår uppmärksamhet på en svampform, som föregående år beskrivits från Ryssland av prof. N. A. Naumov (1926, sid. 6) i Leningrad under namn av *Ligniella pinicola*, och håller för troligt, att den senare kunde vara identisk med vår art. Efter att ha undersökt originalmaterial av denna svamp, som med största beredvillighet tillställts oss av prof. Naumov, ha vi kunnat konstatera, att fullständig identitet mellan den ryska och den svenska formen föreligger.

Pyknidbyggnaden anger dock, att svampen bör föras till det av Saccardo grundade släktet *Discula*, vadan dess namn blir *D. pinicola* (Naumov) Petrak.

Våra renkulturer ha givit oss anledning att urskilja två olika former. Huvudformen utmärkes sålunda av en riklig och snabb pyknidbildning och frånvaro av sklerotieartade mycelbildningar, medan den andra, som vi kallat var. *mammosa*, endast ytterst sparsamt och först efter en längre tids kultur bildar pyknider men i gengäld så mycket rikligare sklerotier (jfr. fig. 31). Någon skillnad i de båda formernas vedblånande förmåga föreligger icke.

En sammanställning av fyndlokalerna för svampen finnes å sid. 211.

Det största intresset tilldrar sig *Discula pinicola* otvivelaktigt som orsak till stämplingsblånad, vilket visat sig vara fallet på Garpenbergs kronopark. Denna blånad utvecklar sig emellertid långsammare än den, som förorsakas av *Endoconidiophora*, och den uppkommande missfärgningen synes ojämnare. *Discula*-blånaden var dessutom till stor del inmängd med stämplingsröta — framkallad av *Stereum sanguinolentum* — och kunde därför icke studeras med samma lätthet.

För undersökning av svampens utveckling på maltagar har använts uteslutande dess var. *mammosa*. Den bildar här ett i början vitt till ljusgrått, glesflockigt, sedermera mer eller mindre brungrått luftmycel (fig. 30); koloniernas undersida blir svartgrön eller rent svart. Tillväxtsiffran är 3,5 (jfr not, sid. 698). Äldre mörkbruna hyfer anta till stor del *Hormiscium*-typ, d. v. s. deras celler voro korta och svällda, stundom nästan klotformade och intill 12 μ tjocka.

Från hyferna direkt avsnöras encelliga och ofärgade konidier, 6,5—9,3 × 2,3—2,8 μ, men sparsamt. I plattkulturerna uppkomma med tiden väl avgränsade, dynformade sklerotier (fig. 31). Troligen måste de uppfattas som stromabildningar, i vilka pyknider av någon anledning utebli. Faktum är,

att det övervägande antalet aldrig förändras. Ja, det kan till och med inträffa, att pyknider icke utvecklas. Detta har exempelvis varit fallet med den stam av svampen, som isolerats från Skoghallsverken 1924. I andra stammar däremot kan man efter lång växttid, kanske först efter ett halvt år eller mera, påvisa pyknider i enstaka stromadynor. Den vanligaste storleken för dessa konidier är c:a 5,6 × 3,7 μ.

Pykniderna ha studerats på mikrotomsnittat material från renkulturerna på maltagar (jfr. fig. 32). De innehålla håligheter av mycket växlande storlek. Deras vägg är ganska tunn och sammansatt av smala hyfer, av vilka de yttre synas vara mera långsträckta. Det innersta skiktet är mera utpräglat parenkymatiskt, och dess ytterst tunnväggiga och plasmafyllda celler utväxa i korta, prylformade, encelliga sterigmer, från vilkas toppar konidier avsnöras (fig. 33 *b*).

Något nytt att tillägga för den rikligt pyknidbildande huvudformen, sådan den utvecklas i agrarkulturerna, finns egentligen icke med undantag av de okulärt iakttagbara olikheter, som redan framhållits.

Den med var. *mammosa* ympade tangentialytan av ett stycke tallved inklädes inom kort i en ljusgrå mycelfilt, i vilken snart uppstå massor av stromadynor. Pyknid däremot ha aldrig framkommit i våra många ympförsök på trä. Veden erhåller en grågrön missfärgning. På klossarnas tvärytor anläggas svarta sklerotier över de i snittet öppnade vertikala hartsgångarna.

Märgstrålarnas parenkym utfylles av nästan raka, tätt packade hyfer, och cellräckorna undergå kraftiga, timglasliknande kontraktioner. I trakeiderna förekomma de också rikligt. Vägen mellan trakeiderna tages genom ringporerna. Men möjlighet till direkt perforation föreligger även, ehuru den tydligen icke anlitas i någon större utsträckning. De perforerande hyferna äro för övrigt så fina, att de icke omedelbart tilldra sig uppmärksamheten.

Från försöken med gran kunna följande detaljer anföras. Hyfernas utveckling i veden förlöper här understundom så, att ingen blånad eller också tämligen svag sådan kommer till stånd (jfr. tavl. I). De förekomma visserligen rikligt både i märgstrålar och trakeider, men äro mycket smala (1—2 μ), något slingrade och grenade samt obetydligt eller icke alls färgade.

Andra ympförsök på granved ha resulterat i en grågrön blånad. Mycelets inträngningshastighet var då ganska betydande.

Återstår nu en redogörelse för huvudformens uppträdande på virke. I naturen ha vi funnit dess kolsvarta konidiestromata i de intorkade strimmor av sekundär bark, som alltid bli kvar på en helbarkad stock. De anläggas inuti denna vävnad, och främträda genom de täckande skiktens sönderspräng-ning. De flesta äro mycket små — mindre än $^1/_2$ mm i tvärmått — de största vi iakttagit nå ungefär 1 mm. Om nu denna form av svampen ympas på trä, tall eller gran, uppstå snart helt ytligt små stromata av den mest växlande form (jfr. fig. 34). På klossarnas tvärytor utvecklas stromadynorna över mynningarna av de avskurna hartskanalerna, vilket står i samband därmed, att de senare även inuti veden kunna utfyllas av en pyknidbildande stromavävnad (jfr. fig. 35). Även i de vida vårtrakeiderna förekommer stroma- och pyknidbildning av alldeles samma slag. I granvirke har den till och med kunnat påvisas i de horisontala hartsgångarna, ehuru den här på grund av utrymmesbrist hålles inom ganska blygsamma gränser.

C. Hyphomyceter.

Hormonema dematioides Lagerberg et Melin nov. gen. et sp.

Våra blåytestudier ha låtit oss komma i beröring med en myceltyp, som genom sin mångformighet erbjuder betydande svårigheter ur systematisk synpunkt. Den hör hemma inom den ytterst vagt definierade *Hormiscium-Torula*-serien av dematiaceerna och står uppenbarligen nära *Dematium pullulans* de Bary, en typ, som blivit ingående behandlad av Neger (1917).

Dess heterogenitet är emellertid obestridlig, och en uppdelning av densamma efter rationella grunder är av behovet påkallad. Det bör då observeras, att denna myceltyp med orätt förts till släktet *Dematium*. Egendomligt nog har den lämnats alldeles obeaktad i den systematiska litteraturen, ehuru den borde vara förtjänt av uppmärksamhet i lika hög grad som många *Hormiscium-* och *Torula*-arter, om vilkas verkliga natur man just intet vet. För att komma ifrån dessa svårigheter ha vi funnit det mest praktiskt att uppställa det nya släktet *Hormonema*, och låta då *Dematium pullulans* i Negers framställning utgöra typen för detsamma.

Sedan den första delen av vår avhandling blivit tryckt, ha vi funnit, att *Dematium pullulans* de Bary redan tidigare av Christine Marie Berkhout (1923) gjorts till typ på ett fristående släkte, kallat *Pullularia*. Då emellertid diagnosen för detsamma endast är meddelad på holländska, måste vår namngivning, som grundar sig på latinsk diagnos, vara den giltiga, trots att den är av yngre datum (jfr. sid. 233).

H. dematioides, som är en viktig blånadssvamp, har dels erhållits från ett antal missfärgade vedprov, men dessutom anträffats som ren epifyt på levande tallbarr i Skogshögskolans park. Härav framgår sålunda, att virkesblånad och sotdagg åtminstone delvis äro beroende av samma eller liknande svampformer. Från samma tallbarr isolerades en andra *Hormonema*-art, som under långvarig kultur på maltagar förblivit ofärgad och därför av oss betecknats som *H. pallida*.

Den mörkfärgade form, som vi ingående studerat, ha vi givit ett nytt artnamn, då det icke varit oss möjligt att avgöra dess eventuella identitet med redan behandlade och namngivna former. Säkerligen är den dock identisk med *Hormiscium gelatinosum* Hedgcock (1906, sid. 101) samt med Willkomms *Xenodochus ligniperda* (jfr. sid. 231 och fig. 41).

De lokaler, från vilka vi isolerat *Hormonema dematioides*, återfinnes å sid. 223.

I renkultur på maltagar utvecklar sig svampen under tvenne alldeles olika former, vilka stå i intimt samband med konidiebildningen. Denna kan nämligen insätta så gott som omedelbart, och då den dessutom kombineras med en ytterst ymnig knoppning, uppstå slemmiga, vitaktiga massor, som helt täcka det radierande mörka hyfunderlaget (fig. 36 *a, b*). Då kulturerna uppdragas från äldre stammar, bildas endast jämförelsevis sparsamt konidier, men i stället uppstår ett olivgrönt, slutligen gråbrunt till mörkbrunt, flockigt luftmycel (fig. 37). Svampens tillväxt är då ganska nedsatt. Medan dess tillväxtsiffra som nyisolerad är 5,5, är den hos luftmycelstypen blott 1,2 (jfr not, sid. 698). Svampens mycket skiftande mycelformer och konidiebildning återges å fig. 38 och 39.

Konidierna, encelliga och ofärgade, växa fram från hyferna praktiskt taget var som helst, enstaka eller gruppvis, understundom så tätt, att de ge intryck

av en regelbunden palissad (fig. 38 *e*, fig. 40). Deras storlek är 6—11 × 3 — 5,25 *μ*.

I tallved framkallar svampen en kraftig missfärgning, mörkgrå med en dragning i olivgrönt, men den är icke homogent spridd, utan lämnar radierande strimmor av ved på ett tvärsnitt mer eller mindre oberörda. Utvecklingen i granved går långsammare, och missfärgningens styrka blir oftast betydligt mindre (jfr. tavl. II).

I tallvirkets inre växer mycelet synnerligen kraftigt och mångformigt. Bl. a. utbildas kortcelliga kedjor av *Hormiscium*-typ, vilka genom nya celldelningar kunna övergå i *Sarcina*-liknande stadier eller rena *Coniothecium*-kroppar (jfr. fig. 41, 42). Det är för övrigt tydligt, att en än mera detaljerad fragmentering av hyferna kan förekomma. Samtidigt försiggår inuti veden en ytterst ymnig konidiebildning. För passage mellan trakeiderna utvälja hyferna uteslutande ringporerna.

Trichosporium tingens Lagerberg et Melin n. sp.

Denna nya art är hittills anträffad på en enda lokal (jfr. sid. 233). Diagnos å sid. 238.

På maltagar utvecklas ett tämligen kraftigt, finflockigt luftmycel av i början ljusgrå färg (fig. 43), vilken med tiden genom gråbrunt övergår i en sotbrun. Koloniernas undersida är då svartgrön eller nästan svart. Tillväxtsiffran är 4,5 (jfr not, sid. 698). Någon specifik lukt utvecklas icke. Konidiebildningen inträder så småningom, och på plattorna uppkomma tämligen talrika, vaddlika, av ljusbruna konidier helt överpudrade dynor (fig. 44), väl 1 mm i diam. Ännu rikligare utbildas sådana på virke. De utgöra i själva verket det bästa igenkänningstecknet på svampen.

På maltagar visa hyferna mycket skiftande växtformer (jfr. fig. 45 *a*, *b*). Konidierna avsnöras dels terminalt från grenspetsarna, dels subterminalt, och det vill även synas, som om en lateral konidiebildning skulle förekomma (fig. 45 *c*). Konidierna äro encelliga, relativt tjockväggiga fullständigt klotrunda och glatta samt med tiden något brunaktiga. Deras diameter växlar mellan 10,5 och 6 *μ*.

Trichosporium tingens hör till de mera aktiva blånadssvamparna, vilket framgår av tavl. II. På det radiära längdsnittet framträda märgstrålanra som svärtade band (fig. 46) och de vertikala hartsgångarna som fina tuschstreck. Tvärsnittet ger en mera blåsvart färgton. Hyferna koncentrera sig på parenkymet, vars cellmenbraner anta olivbrun färg. Mellan trakeiderna går vägen uteslutande genom ringporerna. Särskilt kraftigt utvecklas de hyfer, som förekomma i de vertikala hartsgångarna. Som synes av fig. 47 äro membranerna här belagda med kraftiga utsöndringar, vilka flutit samman till tjocka skidor.

Hormodendrum cladosporioides (Fres.) Sacc.

Denna på virke ytterst allmänna form har isolerats från 10 olika lokaler (jfr sid. 239).

I renkultur på maltagar utvecklar *Hormodendrum cladosporioides* täta, vaddliknande kolonier av till en början grågrön, slutligen grönaktigt gråbrun till brun färg; deras undersida synes olivgrön eller svart (fig. 48). Mycelets tillväxtsiffra är endast 1 (jfr not, sid. 698), men det oaktat inträder konidiebildning (jfr fig. 49 *a*) mycket snart och ytterst rikligt. Konidierna äro encelliga, mer eller mindre

regelbundet ellipsoidiska och försedda med en glatt, olivgrön membran. De isoleras lätt, antingen var för sig eller ock några få i förband (fig. 49 *b*). Storleken är växlande, enligt utförda mätningar 3,7—9,3 × 2,8—5 *μ*. Efter avskiljandet inträda de i livlig knoppning. Även mera basala delar av grenarna i konidieställningarna fragmenteras, och deras isolerade celler fungera som konidier (fig. 49 *c*).

Hormodendrum cladosporioides torde framför andra vara ansvarig för barrvirkets s. k. ytblånad. Våra försök ha emellertid visat, att den under gynnsamma betingelser även kan tränga på djupet i tallved och åstadkomma en intensiv, nästan svart missfärgning (jfr tavl. I). I våravverkat virke blev märgstrålsparenkymet utfyllt av svartbruna och grova hyfer med lika färgade membranskållor. Deras förgrening resulterar ofta i pseudoparenkymatiska förtätningar (fig. 50). Endast ringporerna användas för passage mellan trakeiderna, och de utöva även hos denna svamp ett lokaliserande inflytande på hyfernas grenbildning.

I ympat, vinteravverkat tallvirke utbildades konidieställningar i vårtrakeiderna, som på långa sträckor voro fullproppade av en massa små, olivbruna konidier liksom en patron med hagel. Det var tydligt, att den kraftiga mörkfärgning av vedprovet, som uppkommit efter blott ca. 3 veckor, hade sin väsentliga grund i en inre konidiebildning.

För att *Hormodendrum cladosporioides* skall kunna inträngа i granved erfordras uppenbarligen alldeles bestämda förutsättningar (jfr tavl. I).

Hormodendrum microsporum Lagerberg et Melin n. sp.

Denna nya art har anträffats vid ett enda tillfälle (se sid. 244 och 247). Den har isolerats ur ett blånat stråk, som förekom inom kärnan i stubben av en levande gran och observerades vid granens avverkning. Den ifrågavarande svampen har säkert inträngt från marken. Å den mikroskopiska bilden frapperade omedelbart, att hyferna i huvudsak växte fram genom trakeiderna och visade föga dragning till märgstrålarna (fig. 51), naturligt nog, då parenkymet i kärnveden icke kan verka särskilt tilldragande på grund av sin innehållslöshet. De äldre hyferna voro mörkt olivbruna och grovgryniga av ett nästan svart exsudat (jfr fig. 52). De under rät vinkel utgående sidogrenarna äro utmärkta genom en intensiv perforationsförmåga (fig. 51, 52) och utbilda därvid fotlika, kraftiga adpressorier.

I renkultur på maltagar växer svampen långsamt och till en början huvudsakligen submerst; det så småningom uppkommande luftmycelet blir glest och av ljusgrå färg. I övrigt äro kolonierna mörkt olivgröna, slutligen nästan svarta. Svampen bildade konidier först sedan substratet gjorts surt. Dessa uppstå i rika ställningar, burna av längre eller kortare hyfgrenar, som uppväxa vinkelrätt mot substrathyferna (fig. 53 *a*). Deras storlek uppgår blott till 3,7—5,6 × 2 *μ*.

Leptographium Lundbergii Lagerberg et Melin n. gen. et sp.

Denna form, för vilken vi även grundat ett nytt släkte, ha vi hittills icke erhållit från mer än en lokal (se sid. 248).

I kultur på maltagar blidar svampen ett tämligen glest, trådigt luftmycel av till en början vitaktig färg, som med tiden övergår i en mörkgrå — mörkt brunaktig (fig. 54). Koloniernas undersida blir svartgrön eller nästan

svart. Utvecklingen är snabb, tillväxtsiffran uppgår nämligen till 10 (jfr not, sid. 698). Mycelet utvecklar en lukt, påminnande om sur vört. Konidiebildning inträder snart. Konidierna anhopas i vita, slutligen honungsgula massor på toppen av de avsnörande grensystemen och uppfångas där i en kulformad vätskedroppe. En plattkultur kommer därför att erbjuda stora likheter med en grafiumvegetation (fig. 55). Å fig. 56 äro sammanförda några exempel på den tidigaste konidiebildningens varianter. Den sker icke genom en rent terminal cellbildning — anlagen uppstå nämligen som en sidoriktad utbuktning vid basen av den ännu fastsittande konidien. Konidiebildningen kan även inledas lateralt.

De tidigaste utvecklingsstadierna av de för arten karakteristiska konidieställningarna återfinnas å fig. 57. De utmärkas som utvuxna av en upprepat kvastlik förgrening och bli slutligen så stora, att de utan svårighet synas för blotta ögat. De å fig. 58 återgivna höra till de mindre.

Konidierna äro encelliga, långsträckta hyalina, med tiden brunaktiga, 8—12 × 4—6 μ.

Då *Leptographium Lundbergii* måste betecknas som en fullt distinkt typ, kunde man vänta, att den redan tidigare hade observerats. Vi ha anledning att tro detta, ehuru den blivit förbisedd eller misstolkad. Falck (1916, fig. 82 *c*) synes sålunda ha ansett svampen vara ett konidiestadium av *Ceratostomella Piceæ*. Även Mac Callum (anf. arb. tavl. IX, fig. 19) har tydligen råkat på och avbildat denna svamp i samband med sina studier över samma *Ceratostomella*-art.

På virke utvecklar svampen ett ganska kraftigt gråbrunt—mörkbrunt luftmycel med rikliga konidieanhopningar av klotrund eller ellipsoidisk form. Som blånadssvamp på tallvirke är *Leptographium* en mycket intensiv form och ger inom kort splinten en kraftigt gråsvart missfärgning (tavl. II). Särskilt anmärkningsvärd är rikedomen på grova, längsgående hyfer i trakeiderna. Här finner man dem ofta i slyngor (jfr fig. 59) eller i spiraler utmed väggen. Förgreningen synes i viss mån influeras av ringporernas läge, vilka utgöra den enda vägen för hyferna mellan trakeiderna.

Märgstrålarnas parenkymceller fyllas mer eller mindre fullständigt av grova, bruna hyfer med grova pseudoparenkymlikt packade grenar. De vertikala hartsgångarna synas på det radiära snittet som fina tuschstreck; hyferna ha också här en synnerligen rik utveckling och förekomma i verkliga härvor.

Till granved förhåller sig *Leptographium Lundbergii* mera nyckfullt. Av tavl. II framgår, att det jämförande kulturförsöket på tall- och granvirke för det senare haft negativt resultat, trots det att de ympade träklossarna ägde så lika växtlighetsgrad som möjligt och kulturbetingelserna voro fullständigt de samma. I andra fall har en tydlig men svag blånad uppkommit.

Cadophora fastigiata Lagerberg et Melin nov. gen. et sp.

Denna svamp har isolerats från 7 olika lokaler (jfr sid. 257).

Vi möta här åter en tidigare okänd blånadssvamp, som dock synes ha en mycket vidsträckt utbredning. Den utgör typ för ett nytt släkte (diagnoser å sid. 263). På maltagar bildar den ett tätt luftmycel av ljusgrå eller ljust grågrön färg, som så småningom överföres i en mer eller mindre gråbrun (fig. 60). Koloniernas undersida blir slutligen svartbrun eller rent svart. Deras utveckling förlöper långsamt, tillväxtsiffran är blott 1,2 (jfr not, sid. 698).

Mycelet visar stor benägenhet för strängbildning (fig. 62, 63). I plattkulturer uppstå sålunda flera millimeter långa, pisksnärtliknande koremier, som vid basen kunna innehålla över 50 hoplödda hyfer men uppåt allt mer avtunnas, då de enskilda hyferna frigöras ur förbandet och utveckla konidieställningar.

Konidiebildning inträder snart och är endogen. Konidierna uppstå nämligen i flasklika behållare av något växlande form. Även förekomma sådana av mera långsträckt typ (fig. 60). De enskilda konidiogonen anläggas här till en början terminalt, men snart tillkomma nya subterminala och även laterala (fig. 61 *d*). Hela samlingen blir kvastlik eller bollformad och synes under lupförstoring som en mörk kula. Varje behållare har en begränsad produktion. Konidierna äro encelliga, ellipsoidiska, ytterst tunnväggiga, till en början fullständigt hyalina men med tiden svagt brunskiftande, 4—6,7 × 2—2,7 *μ*.

Svampen inträngер med lätthet i tallvirke, som därvid erhåller en kraftig, svartgrå missfärgning (tavl. II). Hyferna anträffas massvis i märgstrålarnas parenkym, och deras växtsätt därstädes och allmänna utseende ange en viss överensstämmelse med *Ceratostomella pluriannulata*. De ha förmåga att direkt perforera trakeidernas väggar, varvid adpressorier av samma typ som hos *Ceratostomella*-arterna utbildas.

Svampens förhållande till granved är mycket växlande. Ibland uteblir blånad fullständigt (jfr tavl. II).

Alternaria humicola Oudemans.

Denna svamp är anträffad vid ett enda tillfälle (jfr sid. 263).

På maltagar bildas ett tätt luftmycel av till en början vit, sedermera grågrön till olivgrön och slutligen gråbrun färg (fig. 64). Koloniernas undersida blir svartgrön. Deras tillväxtsiffra är 2,8 (jfr not, sid. 698). Hyfernas celler äro ofta mantelformade, stundom korta och något svällda, till färgen grönaktigt olivbruna, och hyferna bilda slyngor och anastomoser (fig. 65).

Konidier uppstå som encelliga klamydosporer, i vilka emellertid snart en livlig väggbildning inledes (fig. 66 *a*). Ofta anläggas de i rader med enkla celler som mellanled eller ock i mer eller mindre sammansatta racemösa grupper, som bäras av korta sidogrenar på substrathyferna (fig. 66 *b*, *c*). Membranen blir slutligen mörkbrun eller svartaktigt olivbrun och erhåller en fin chagrinering av oregelbundna, kantiga skållor (fig. 66 *d*). Storleken är 21,4—53,6 × 14,3—17,9 *μ*.

Svampen inträngер med lätthet i tallvirke, som erhåller en grönaktigt grå missfärgning (tavl. II). De i märgstrålsparenkymet framväxande hyferna utfylla stundom fullständigt avståndet mellan de trakeidala kantcellerna. Även i trakeiderna äro hyfer vanliga, i regel tämligen raka men med rikliga sidogrenar; de senare visa sig besitta en utpräglad perforationsförmåga och utbilda kulformade adpressorier.

I granved växer svampen sämre (jfr tavl. II); missfärgningen yttrar sig endast som en smutsigt grönaktig skiftning.

I samband med blånad ha *Alternaria*-arter redan varit föremål för uppmärksamhet. Sålunda upptar Hedgcock (1906, sid. 103) i den grupp, som endast framkallade en ytblånad på splintved, *Alternaria tenuis* Nees, dock utan vidare beskrivning. Även hos Kress (1925, sid. 65) omnämnes en

Alternaria såsom allmän på slipmassa; artbestämning har ej blivit utförd, men svampen visar stor likhet med *A. humicola*. Den senare anträffades ursprungligen som humussvamp i Holland av OUDEMANS (1902), varför man kan förmoda, att den bör ha en vidsträckt spridning.

Xylomyces I.

Svampen har anträffats vid ett enda tillfälle (sid. 267).

Under ovanstående provisoriska beteckning omnämna vi här ett mycel, som trots långvarig kultur på de mest olika substrat icke kunnat förmås att reproducera sig. Som blånadssvamp har det emellertid visat sig vara så aktivt, att vi icke velat förbigå detsamma i vår framställning (jfr tavl. II). Till sin allmänna habitus erinrar svampen rätt mycket om det likaledes sterila mycel, som en av oss (MELIN 1921, sid. 196; 1923, sid. 223) isolerat ur barrträdens mykorrhiza, och som kallats *Mycelium radicis atrovirens*.

Svampens utveckling på maltagar går mycket långsamt; tillväxtsiffran är endast 1 (jfr not, sid. 698). Luftmycelet blir emellertid tätt och kraftigt (fig. 67) och har i början en mullvadsgrå, sedermera gråbrun färg. Undersidan av kolonierna är svartbrun.

Mycelet växer ungefär lika kraftigt på tall som på gran. Här framkommer i lufthyferna en svagt olivgrön färg, som så småningom ändras till gråbrun. Inträngningsförmågan har yttrat sig något olika vid skilda försök, men på det hela taget uppkommer den kraftigaste blånaden i tall. Svampen är väl karakteriserad genom sina smala, jämna och långcelliga hyfer, som ange påtaglig likhet med *Cadophora fastigiata*. Direkta perforationer av trakeidväggarna saknas.

Penicillium biforme THOM.

Ovanstående art har erhållits i renkultur från 3 lokaler (sid. 268).

Den av oss studerade *Penicillium*-arten utvecklar på maltagar ett tätt luftmycel, som under de första dagarna har en rent snövit färg. Med inträdande konidiebildning bli kolonierna ljust grågröna men bibehålla ett vitt kantbräm (fig. 68). Å äldre kolonier är även det senare fullständigt försvunnet, därför att konidiebildningen förts fram ända ut i kanten. Färgen förändras under tiden och slutar i en ganska mörkt gråbrun, i vilken endast en svag anstrykning av grönt kan skymtas. Koloniernas undersida förblir hela tiden smutsigt gulvit. Deras utveckling fortskrider på det hela taget ganska långsamt; tillväxtsiffran är blott 1,5 (jfr not, sid. 698).

Konidiebildning sker huvudsakligen från korta, uppstigande sidogrenar, till en början å ställningar av en ganska enkel typ (fig. 69). Hela konidieställningen blir ganska smalt penselformad, och konidierna sammanhållas länge i pärlbandslika, buktande rader. Deras form är övervägande klotlik — en och annan svagt ellipsoidisk förekommer dock alltid i preparaten — och storleken är rätt ojämn, färgen slutligen mörkt olivgrön; diametermåtten växla mellan 4,7 och 3,1 μ. I täckglaskulturerna uppstodo rätt ofta submersa konidieställningar.

På tallvirke utvecklar *P. biforme* en svag, tämligen ytlig blånad, utmärkt av en viss strimmighet (tavl. II). På ett radiärt längdsnitt av ett ympat tallvedsstycke kunde okulärt urskiljas fina, skarpt ärggröna streck. Dessa utgjordes av breda märgstrålar, helt utfyllda av hyfer med tämligen vida och

tunnväggiga celler. I trakeiderna förekomma hyfer ganska sparsamt, förmåga av direkt perforation ha de icke. Liksom hos *Hormodendrum cladosporioides* utvecklas konidieställningar inne i veden ganska allmänt. I första hand synas de vidare vårtrakeiderna utväljas härför, men konidieställningar saknades icke heller i hösttrakeiderna. Långa sträckor voro alldeles fullproppade av konidiemassor, och det var uppenbart, att just dessa utfyllnader bidrogo till att framkalla den missfärgning, som kunde iakttagas med blotta ögat. Mycelet saknar också fullständigt förmåga att perforera trakeidväggarna. *P. biforme* är en av »ytblånadens» mest typiska svampformer.

Å granved erhölls vid ympförsöken icke någon missfärgning.

5. Yttre faktorers inverkan på blåytesvamparnas utveckling.

De faktorer, som påverka blåytesvamparnas utveckling i virket, äro i främsta rummet vatten- och syrehalten, temperaturen samt virkets kemiska och fysikaliska beskaffanhet.

A. Vatten- och syrehaltens inverkan.

Vid våra undersökningar över vattenhaltens inverkan på blåytesvamparnas utveckling i virket, ha vi begagnat oss av ungefär lika stora sektorer av tall och gran. Dessa ha gjorts tämligen små, så att vid den partiella uttorkningen eller vatteninsugningen så likformig vattenhalt som möjligt skulle erhållas i splinten. De hade en största bredd av 3 cm och en höjd av 3,5 cm. Sedan den avsedda vattenhalten genom vattendränkning eller uttorkning[1] ungefärligen ernåtts, insattes sektorerna (såvida annorlunda ej angives) i termostat vid 50° C, där de höllos i slutna glaskärl under två dygn. Härigenom ernåddes en partiell sterilisering, vilken i de flesta fall var nödvändig. Sektorernas styckning, partiella uttorkning, vattendränkning m. m. har nämligen ej kunnat utföras under aseptiska förhållanden och dessutom har det använda virket i en hel del fall avverkats tämligen långt före försökens början och därför redan varit infekterat av blåytesvampar eller andra mycel.

Talrika förberedande försök visade, att såväl blåytesvamparnas som vanliga mögelsvampars mycel och konidier dödades genom detta förfaringssätt, något som också bekräftats genom en mängd senare kontrollförsök. Under det att ej behandlade sektorer kraftigt infekterats av *Hormodendrum, Penicillium, Trichoderma* m. fl., ha nämligen partiellt steriliserade sektorer, som hållits under samma förhållanden som de förra, förblivit fria från synbart svampangrepp under flera veckor. Att även vedförstörande hymenomyceter dödas i fuktighetsmättad luft vid nämnda temperatur, framgår av Snells (1923) undersökningar. Däremot synas i virket möjligen förekommande bakterier i allmänhet ej dödas genom denna metod. Emellertid ha bakterierna endast sällan kunnat påvisas i virket. Endast i försöken med länge vattendränkt virke, (jfr tab. 20) ha de förekommit i större utsträckning. Möjligen ha de i dessa fall något påverkat blåytesvamparnas utveckling. Å andra sidan har dock samtidigt den fördelen ernåtts, att förhållandena i största möjliga utsträckning kommit att likna dem i naturen.

[1] Vatteninsugningen skedde vid rumstemperatur; den partiella uttorkningen utfördes vid c:a 30° C i torr luft. För att uppnå den lägsta använda fuktighetsgraden, erfordrades c:a 10 timmar.

En fullständig sterilisering av virket — i autoklav eller ångsterilisator — har undvikits, emedan veden vid högre temperatur undergår högst väsentliga förändringar. Vid 50° C torde däremot den fysikaliska och kemiska (inkl. biokemiska) strukturen högst oväsentligt förändras.

Det framgick genom förberedande försök, att blåytesvamparna — åtminstone en del arter — utvecklades betydligt bättre i partiellt steriliserad än i autoklavsteriliserad ved. En extrem typ i det avseendet är *Trichosporium tingens*, som utväxer kraftigt i det förra fallet (i synnerhet på tallvirke), däremot ej alls i det senare. Det partiellt steriliserade virket är dessutom något gynnsammare för svamparnas inträngande än obehandlat. Detta torde huvudsakligen bero på att i det förra konkurrensen med ovan nämnda infektionssvampar upphävts.

Efter den partiella steriliseringen neddoppades hastigt halva antalet sektorer en och en i smält aseptiskt paraffin (c:a 90° C), varvid endast tangentialytan lämnades intakt. Sedan paraffinet stelnat, upprepades neddoppningen ytterligare två gånger. Denna åtgärd vidtogs för att förhindra luftens inträngande från snittytorna under försökens lopp. Vid de orieterande försöken användes ej paraffinerade sektorer.

Sektorerna ympades med en konidieemulsion eller, i de fall konidier ej bildats, med hyfer. I det förra fallet beströks — så likformigt som möjligt i de skilda försöken — ett centralt bälte längs hela tangentialytan med konidieuppslamningen medelst en platinaögla, i det senare fallet — försöken med *Xylomyces* 1 — överfördes hyfer till tangentialytans centrum. Uteslutande renkulturer ha tjänstgjort som ympmaterial. De ympade sektorerna förvarades vid rumstemperatur i burkar å 750 cm^3 med inslipat lock eller i öppna steriliserade bägare under glasklockor.

Vid försökens slut kontrollerades, att luftinfektion ej inträffat, i vilket fall sektorerna kasserades.

Sektorerna styckades genom tvärsnitt i två delar, av vilka det ena användes för undersökning av blånadens utveckling, det andra för bestämning av splintens vattenhalt.

Den blånade delen av tvärsnittet avritades planimetrerades och beräknades därefter i procent av hela tvärsnittsytan.[1] De härvid erhållna värdena uttrycka ej fullt exakt blånadens procentuella volym i sektorn, enär svamparna kunna ha utvecklats något annorlunda i de centrala delarna. I allmänhet äro värdena något för höga. Felet torde emellertid i allmänhet ej vara större än 5 %. Övriga felkällor, som vidlåda metoden, och som orsakas av mindre olikheter i sektorernas längd, olikformighet i virket och olikheter beträffande det tillförda ympmaterialets storlek, äro likaså i stort sett tämligen små. Detta förhållande belyses av tab. 11.

Självfallet äro de nämnda procentsiffrorna jämförbara med varandra endast inom en och samma försöksserie, där sektorer från samma virke — alltså med samma diameter och splintvolym — använts. Vid en jämförelse mellan blånadens utsträckning i olikartade sektorer bör lämpligast djupet för blåytesvamparnas inträngande från tangentialytan användas som måttstock. Det bör emellertid framhållas, att därvid ej sällan mycket missvisande värden kunna erhållas, nämligen i de fall då blånaden uppträder kilformat i virket.

[1] Vid de orienterade försöken mättes endast blånadens radiära utsträckning från tangentialytan.

Enär hyferna från den ympade tangentialytan inträngа huvudsakligen i radiär riktning i märgstrålarna, äro i ifrågavarande fall såväl det procentuella blånadstalet som den radiära utsträckningen uttryck för blånadssvamparnas tillväxthastighet i virket.

Blånadens färgstyrka har angivits med en tregradig skala (X—XXX).

Vattenhalten bestämdes såvida ej annorlunda angivits — i splintens yttre 20 mm. Av den för vattenbestämningen avsedda sektorhalvan utskars ett parallellipipediskt, 20 mm brett och 20 mm djupt stycke, som efter vägning uttorkades vid 100° C. Vattenhalten uttryckes dels i procent av torrsubstans (I), dels i procent av vattenkapaciteten.[1] Den på det senare sättet uttryckta vattenhalten kan lämpligen i enlighet med KINNMAN (1925, sid. 21) beräknas som virkets mättningsgrad. Det visade sig nödvändigt att bestämma vattenhalten (I) i varje sektor, enär densamma varierade tämligen avsevärt även hos sektorer, som uttorkats under lika lång tid.

Undersökningsmaterialet har utgjorts dels av virke med primärt fritt vatten, dels av virke med sekundärt fritt vatten. Det senare virket hade efter avverkningen styckats i sektorer och lufttorkats. Efter 6 månaders lagring i torrt rum hade det vattenlagts under 2 månader, varvid vattnet i regel ombytts var tredje dag. Avsikten härmed var att utröna, huruvida svamparna förhöllo sig annorlunda i färskt än i en gång lufttorkat virke.

Undersökningen har givit vid handen, att svamparna delvis förhålla sig väsentligt olika i virke med primärt fritt vatten och i virke med sekundärt fritt vatten. I anslutning till de nedan meddelade praktiska försöken över olika lagringsformers inverkan på blåytans utveckling i lagrat rundtimmer intresserar oss här mest svamparnas blånadsförmåga i virke av den förstnämnda typen. Försöken med virke av den senare typen äro emellertid även praktiskt viktiga. De belysa exempelvis förhållandena i sågat, en gång lufttorkat virke, som utsättes för väta.

Av virke mot primärt fritt vatten har undersökts såväl tall- som granvirke.

I det undersökta vinteravverkade tallvirket ha svamparnas tillväxthastighet och blånadsintensitet i stort sett ej varit densamma i paraffinerade och ej paraffinerade sektorer. I försöksserie 3 ha vid naturlig vattenhalt (70 % mättningsgrad, 145 % I) samtliga undersökta arter, nämligen *Ceratostomella cærulea, Discula pinicola, Trichosporium tingens* och *Leptographium Lundbergii*, haft en ytterst obetydlig blånadshastighet i de paraffinerade sektorerna. Efter tre veckor ha hyferna från tangentialytan inträngt högst 2 mm och ha orsakat endast en mycket svag, delvis knappast märkbar missfärgning. Förhållandet har i stort sett varit detsamma, om vattenhalten i splinten ökats med c:a 10 %. I de ej paraffinerade sektorerna ha i samma försök vid naturlig vattenhalt endast *Discula pinicola* och *Trichosporium tingens* kraftigt hämmats eller hindrats att inträngа i veden, under det att *Ceratostomella cærulea* och *Leptographium Lundbergii* orsakat en blånad av resp. 13 och 25 % av sektorerna. Av de båda senare arterna har endast *C. cærulea* undersökts i sitt förhållande till högre vattenhalt än den naturliga, nämligen 83 % II (171 % I), vid vilken hyferna förmått inträngа endast c:a 1 mm från ytan, förorsakande en mycket svag färgning.

En vattenförlust av c:a 10 % har varit tillräcklig i de ej paraffinerade sektorerna, för att svamparna skulle nå sitt utvecklingsoptimum (*Trichosporium*

[1] Vattenkapaciteten bestämdes i det nyfällda virket.

tingens och *Leptographium Lundbergii),* under det att i paraffinerade sektorer detta nåtts först vid en vattenförlust av 57—77 %. I det förra fallet visa svamparna en bred optimal zon, som sträcker sig från omkr. 61—67 % mättningsgrad (116—137 % I) till omkr. 20 % mättningsgrad (40 % I), i det senare däremot ett starkt begränsat optimum, som för de skilda arterna ligger något olika, nämligen vid c:a 17—30 % rel. vh. (c:a 34—62 % abs. vh.).

Den undre gränsen för tillväxten synes ligga vid samma vattenhalt i paraffinerade och ej paraffinerade sektorer, ehuru olika arter härvid förhållit sig något olika. I det ifrågavarande tallförsöket låg den undre utvecklingsgränsen för:

Ceratostomella cærulea omedelbart under 27 % abs. vh.,

Discula pinicola, Trichosporium tingens, Leptographium Lundbergii omedelbart ovanför 28—29 % abs. vh.

Av de i försöksserie 4 undersökta arterna ha *Hormonema dematioides, Hormodendrum cladosporioides* och *Alternaria humicola* givit tillväxtkurvor (fig. 75—77) av ungefär samma utseende som de nyss nämnda arterna, även om den övre gränsen ligger vid något högre vattenhalt hos de förra än hos de senare. *Hormodendrum* och *Alternaria* visade i paraffinerade sektorer en jämförelsevis obetydlig tillväxt vid 70 % mätningsgrad (155 % I), under det att *Hormonema* vid samma vattenhalt hade utvecklats tämligen kraftigt. Tillväxten stegras i samtliga fall successivt vid minskad vattenhalt till omkr. 35 % vattenhalt I (16 % II). I de ej paraffinerade sektorerna har den optimala zonen nåtts redan vid omkr. 70 % mättningsgrad (155 % I).

Ceratostomella Pini representerar en från de övriga undersökta arterna avvikande typ, i det att såväl i paraffinerade som ej paraffinerade sektorer tillväxtkurvorna nått sitt maximala läge redan vid 73—77 % mättningsgrad (163—171 % I).

Orsaken till svamparnas i stort sett olika utveckling i paraffinerade och ej paraffinerade sektorer torde närmast vara den, att luftväxlingen varit olika livlig. Blånadssvamparna äro, såsom MÜNCH (l. c.) framhållit, och som vi kunnat bekräfta beträffande de av oss isolerade arterna, strängt aëroba organismer. I vinteravverkat virke med naturlig vattenhalt har uppenbarligen syrehalten i de flesta fall varit för liten i splintens yttre delar, för att svamparna skulle kunna trivas. Om därför syre under försökets lopp hindrats inträngа från snittytorna (försöken med paraffinerade sektorer), ha svamparna — undantag *Ceratostomella Pini* och *Hormonema dematioides* — under tre veckor kunnat inträngа endast i de yttersta årsringarna. Om sektorerna ej paraffinerats, har däremot en så stor mängd syre indiffunderat, att de flesta arterna kunnat nå en tämligen kraftig utveckling. Bäst ha *Ceratostomella Pini* och *Hormonema dematioides* utvecklats, som redan vid 2—3 % vattenförlust nått sin optimala tillväxthastighet. Den av *Ceratostomella cærulea* och *Leptographium* orsakade blånaden var mest intensiv invid snittytorna, där luftväxlingen och därmed syretillgången uppenbarligen varit störst. För *Discula pinicola* och *Trichosporium tingens* har syretillgången i splinten vid naturlig vattenhalt varit för liten för att de skulle finna trevnad.

I de partiellt uttorkade sektorerna har den för svamparna gynnsammaste syrehalten erhållits vid en vattenförlust av 60—80 %, om sektorerna paraffinerats (undantag *Ceratostomella Pini),* däremot redan vid en vattenförlust av c:a 10 % om sektorerna paraffinerats (undantag *C. Pini* och *Hormonema de*

matioides). En ytterligare ökning av syretillgången vid fortsatt uttorkning medför i det senare fallet ej stegrad tillväxt, utan kurvorna förlöpa horisontalt, tills de på grund av vattenbrist hastigt sjunka. Orsaken till att syretillgången i ej paraffinerade sektorer varit för svamparna optimal redan vid svag uttorkning torde vara att söka däri att genom luftväxlingen nytt syre successivt tillförts under försökets lopp.

Av försöken måste emellertid slutas, att ej alla arterna ha samma syrekrav. Till de mest syrebehövande höra *Discula pinicola* och *Trichosporium tingens.* Något mindre fordrande äro *Ceratostomella cœrulea, Leptographium Lundbergii, Hormodendrum cladosporioides* och *Alternaria humicola* och minst fordrande slutligen *Hormonema dematioides* och *Ceratostomella Pini.* Den sistnämnda arten hade i paraffinerade sektorer nått sitt utvecklingsoptimum redan vid en vattenförlust av 7 % (73 % mättningsgrad), under det att *Hormonema* vid samma vattenhalt orsakat en blånad, som var 40 % av den maximala.

Det framhölls ovan, att den maximala blånadsprocenten i allmänhet ej varit lika stor i paraffinerade som i ej paraffinerade sektorer (jfr fig. 70—73, 76—77). Denna olikhet synes oss böra förklaras så, att i det förra fallet svamparnas optimala syrekrav aldrig uppnåtts. På grund av otillräcklig syretillgång skulle sålunda de flesta svamparna i paraffinerade sektorer aldrig kunnat nå fullt optimal utveckling.

Ceratostomella Pini och *Hormonema dematioides* utgöra även härutinnan ett undantag (fig. 74 och 75). Mest påfallande är detta förhållandet med den förstnämnda arten, som från 73 % mättningsgrad (163 %) till 18 % mättningsgrad (39 % I) utvecklats lika kraftigt i paraffinerade och ej paraffinerade sektorer. Uppenbarligen sammanhänger detta förhållande med ett mindre syrebehov hos ifrågavarande arter.

Det för undersökningarna använda granvirket har ej varit lika gynnsamt för svamparna i skilda försök. Såväl i det vår- som vinteravverkade virket i försöksserie 2 utvecklades *Endoconidiophora cœrulescens* mycket hastigt och orsakade intensiv blånad, under det samma art i försöksserie 5 tillväxte betydligt långsammare och åstadkom mindre kraftig blånad. Osaken till denna olikhet torde delvis sökas däri, att virket i de första fallen varit mera frodvuxet än i det senare. Dessutom kan dock möjligen förefinnas vissa kemiska skillnader, vilket kommer att ytterligare beröras senare. Ett flertal blåytesvampar förhålla sig gentemot granvirke ytterst nyckfullt. I en del fall kunna de utvecklas kraftigt, i andra fall däremot svagt, utan att några väsentliga olikheter med avseende på virkets årsringstäthet förefunnits.

De fullständigaste kulturförsöken på gran vid olika vattenhalt ha gjorts på virke, som synbarligen varit mindre gynnsamt (försöksserie 5). De kunna därför ej generaliseras utan gälla endast för granvirke av den för svamparna mindre fördelaktiga typen. Den för ifrågavarande försök avverkade granen hade en abnormt låg vattenhalt i splinten, nämligen 47 % mättningsgrad (85 % I). Trots denna låga vattenhalt inväxte ej *Endoconidiophora cœrulescens, Hormonema dematioides* och *Xylomyces* I i det nyfällda virket. Förhållandet var detsamma i paraffinerade och ej paraffinerade sektorer. En obetydlig vattenförlust har emellertid gjort virket gynnsammare för svamparna, och den optimala tillväxten uppnås hastigt vid partiell uttorkning. Den optimala zonen ligger vid ungefär samma vattenhalt i paraffinerade och ej paraffinerade sektorer, nämligen för *Endoconidiophora* mellan c:a 41 och 32 % mättningsgrad

(74—57 % I), för *Hormonema* och *Xylomyces* I mellan c:a 46 och 28 % mättningsgrad (c:a 82—50 % I). Den undre gränsen för blånadsförmågan ligger för den förra arten vid c:a 40 % vattenhalt, för *Hormonema* och *Xylomyces* 1 vid c:a 30 %.

I för svamparna mera gynnsamt granvirke gjordes endast försök med *Endoconidiophora cœrulescens*. Sektorerna hade ej paraffinerats. Vid naturlig vattenhalt utvecklades denna kraftigt och hade efter 30 dygn inträngt 35 mm. Vid 6 % vattenförlust har tillväxtkurvan nått sitt maximala läge, som bibehålles till bortåt 40 % abs. vh., varefter den hastigt sjunker. Den undre gränsen ligger omedelbart ovanför 34 % vattenhalt I. Kurvan för *Endoconidiophora* överensstämmer nära till sitt förlopp med tillväxtkurvorna för flertalet på tall undersökta arter.

Det har ett visst intresse att jämföra svamparnas förhållande i för dem ogynnsamt och gynnsamt virke. Förutom skillnaden i tillväxthastighet och blånadsintensitet vid optimal vattenhalt finner man betydande olikheter beträffande övre och undre gränserna för blånadsförmågan. Isynnerhet gäller detta övre gränsen. Den övre gränsen ligger i frodvuxet tallvirke och betydligt högre vattenhalt än i för svamparna mindre lämpat virke. Utom för *Endoconidiophora* kunna härvid direkta jämförelser göras beträffande *Hormonema*, vars övre gräns i tallförsöket (försöksserie 3) låg ovanför 76 % mättningsgrad, i granförsöket (försöksserie 5) däremot under 49 % mättningsgrad i båda fallen i ej paraffinerade sektorer[1]. Man har sålunda anledning antaga, att svamparnas syrekrav ökas, om förhållandena i övrigt äro på ett eller annat sätt ogynnsamma.

De utförda försöken bekräfta de resultat, till vilka Münch (1908, 1909) kommit beträffande *Ceratostomella Pini* och *C. cœrulea*, nämligen att syretillgången är den för svamparnas tillväxt bestämmande faktorn vid hög vattenhalt i virket. Veden måste innehålla en bestämd kvantitet syre för att svamparna skola trivas och orsaka blånad. Syret kan ej transporteras genom mycelet utifrån utan måste finnas i veden, där det skall förbrukas. Det har emellertid som nämnt framgått av försöken, att ej alla blåytesvampar ha samma syrekrav. Till de minst fordrande i detta avseende höra *Ceratostomella Pini, Endoconidiophora cœrulescens* och *Hormonema dematioides*. Dessutom synes klart framgå, att syrebehovet ökas i den mån, som förhållandena i övrigt äro ogynnsamma för svamparna.

I stående träd synes den yttre splinten normalt innehålla för litet syre för de flesta blåytesvamparna. Åtminstone är detta fallet under vintern, då splintens vattenhalt är större än under sommaren (jfr nedan). Däremot finnes i den inre splinten, där vattenhalten är mindre, tillräckligt mycket syre, för att åtminstone en del arter skola kunna utvecklas. *Endoconidiophora cœrulescens* och *Discula pinicola* hade som ovan nämnts inträngt från genom stämpling åstadkomna sårytor i växande gran och hade i den inre splinten orsakat en kraftig blånad.

I våra försök med vinteravverkad tall och gran vid naturlig vattenhalt inträffade ofta, att svamparna från snittytorna inträngde i den inre splinten,

[1] Det kan i samband härmed erinras om att i de i Ser. 7 meddelade granförsöken (frodvuxet virke med sekundärt fritt vatten) den övre gränsen för tillväxten av *Hormonema* och *Xylomyces* 1 ligger högre än 60 % mättningsgrad (125 % I), sålunda högre än i de nämnda försöken med senvuxen gran.

som därvid intensivt färgades, under det att yttre splinten förblev intakt. Detta var isynnerhet fallet med *Ceratostomella cærulea, Trichosporium tingens* och *Leptographium Lundbergii*. Liknande iakttagelser gjorde MÜNCH (1908, 1909) vid sina försök. Denna företeelse kan endast bero därpå, att syrehalten varit större i splintens inre än i dess yttre delar[1].

Det är sålunda påtagligt, att den yttre splinten i stående träd utgör en skyddande barriär emot blåytesvamparnas inträngande. Om däremot efter avverkning vatten avgår, intränger i stället luft i cellerna, och förhållandena bli därigenom gynnsammare för svamparna. Ju större vattenavgivningen är, desto bättre trivas dessa intill en bestämd gräns. I timmer av frodvuxen vinteravverkad tall torde de — liksom i de paraffinerade sektorerna — nå sin optimala utveckling först vid en vattenförlust i splinten av c:a 60—80 %, såvida ej sprickor uppkommit, som underlätta luftväxlingen. Däremot inträffar optimum redan vid en tämligen obetydlig vattenförlust i exempelvis sågat virke, där — i likhet med förhållandena i ej paraffinerade sektorer — syre med större lätthet kan indiffundera. Samma är förhållandet exempelvis i finare dimensioner av sågat virke.

I MÜNCHS ovan nämnda försök med *Ceratostomella cærulea* på vinteravverkad tall når kurvan för blånadshastigheten sitt maximum vid c:a 35 % vattenförlust, varefter den synes förlöpa ungefär horisontalt till c:a 70 % vattenförlust[1]. MÜNCHS kurva stegras sålunda betydligt långsammare än kurvorna för våra oparaffinerade tallsektorer, men däremot avsevärt hastigare än kurvorna för de paraffinerade. Orsaken till dessa olika resultat torde få sökas i de olika försöksanordningarna. MÜNCH använde som nämnts 10—12 cm höga, ej paraffinerade stamtvärsnitt. Uppenbarligen har luftväxlingen i dessa varit större än i våra paraffinerade sektorer, men däremot mindre än i våra oparaffinerade. Det är möjligt, att blånadsmaximum i fällda, frodvuxna träd kan nås redan vid en vattenförlust av 35 % i överensstämmelse med MÜNCH, nämligen om det är fråga om små dimensioner. De nedan meddelade praktiska försöken tala emellertid för att våra resultat med paraffinerade sektorer i stort sett mera överensstämma med förhållandena i lagrat timmer.

Sedan blånadsmaximum uppnåtts, är det den för hyferna tillgängliga vattenmängden, som är avgörande för deras tillväxtintensitet. Man kan säga, att blånadsförmågan praktiskt taget upphör, då det ej längre finnes fritt vatten i cellerna, d. v. s. vid den s. k. fibermättningspunkten. Olika arter förhålla sig emellertid något olika beträffande den undre gränsen. Så ligger exempelvis gränsen för utvecklingen av *Endoconidiophora cærulescens* något högre än för övriga undersökta arter.

Betrakta vi så förhållandena i en gång lufttorkat virke, så finna vi, att flertalet svampar här trivas sämre än i virke med primärt vatten. Det förefinnes emellertid en påtaglig skillnad mellan å ena sidan pyrenomyceterna samt pyknidsvamparna och hyphomyceterna å andra sidan. De förra ha nämligen antingen ej orsakat någon blånad *(Endoconidiophora cærulescens, Ceratostomella Piceæ)* eller också en ytterst svag sådan *(Ceratostomella cærulea)*. Den av hyphomyceterna alstrade blånaden var i de flesta fall *(Hormonema, Trichosporium, Leptographium, Xylomyces* 1) svagare framträdande än i virke med

[1] Delvis kan detta syre härröra från atmosfärisk luft, som på grund av negativt tryck i det stående trädet indiffunderat efter avverkningen.

primärt vatten. Pyknidsvampen *Discula pinicola* hade däremot i båda fallen orsakat en blånad av ungefär samma färgstyrka.

Det är påtagligt, att virket genom uttorkningen och den därpå följande vattenläggningen genomgått vissa för de flesta arterna ogynnsamma förändringar. Såsom nyavverkat hade samma virke undersökts i förhållande till *Ceratostomella cærulea, Endoconidiophora cærulescens* och *Trichosporium tingens,* vilka alla utvecklades mer eller mindre kraftigt. Det är sannolikt, att de övriga arterna skulle ha förhållit sig på samma sätt.

Vilka förändringarna äro, kan för närvarande ej avgöras. Det ligger närmast till hands att antaga, att det är fråga om en urlakning tack vare sektorernas vattenläggning, kombinerad med jäsningsprocesser genom bakterier, varigenom den ursprungliga halten av assimilater decimerats.

Att en del organiska föreningar försvunnit eller ombildats, har direkt kunnat påvisas. Så innehöllo exempelvis märgstrålarna i gransektornrna från början rikligt stärkelse, som däremot ej kunde påvisas efter vattenläggningen. Men å andra sidan fanns i såväl tall- som gransektorerna rikligt fett, som borde kunnat utgöra en god kolkälla för svamparna.

Sannolikt hava även andra orsaker bidragit till svamparnas mindre kraftiga utveckling. Möjligen ha genom mikroorganismer vissa för blånadssvamparna skadliga ämnen bildats.

Det är emellertid praktiskt viktigt att fastslå, att även en gång lufttorkat virke efter förnyad vatteninsugning utsättes för blånad, även om de angripande arterna äro till antalet mindre och blånaden ofta mindre kraftig än beträffande färskt virke. Isynnerhet för det sågade virkets vidkommande är denna fråga av betydelse. Även sedan detta blivit fullständigt lufttorkat, måste det skyddas mot vatten. En omlagring eller inlastning under regnväder kan sålunda få mycket fördärvliga följder, detta så mycket mera som blånadsgränsen ligger vid så låg vattenhalt som omkring 30 % av torrsubstansen.

B Temperaturens inverkan på blåytesvamparnas utveckling.

(Fig. 83—84).

Kulturerna utfördes i petriskålar på maltagar. Sedan normala kolonier utbildats, mättes tillväxten längs fyra radier i anslutning till Falcks metod (Falck 1907, Melin 1925).

Resultatet meddelas i fig. 83 och 84. Det framgår, att *Endoconidiophora cærulescens* och *Leptographium Lundbergii* har ett tämligen begränsat optimum på maltagar, den förra vid 22,5° C, den senare vid 25° C. De övriga undersökta arterna däremot ha en bred optimal zon, som i allmänhet kulminerar vid c:a 22,5° C, med undantag av *Xylomyces* 1, som på maltagar har sitt optimum vid c:a 19° C. Temperaturminimum har ej fastställts, men torde ligga vid eller omedelbart ovanför nollpunkten. Vid 3—4° C. har nämligen fortfarande en tillväxt på maltagar kunnat påvisas [1]. Temperaturmaximum ligger ovanför 27° C.

Wolpert (1924) har nyligen beträffande vedförstörande svampar kommit till det resultatet, att den optimala temperaturen till en viss grad växlar med substratet. Trots dessa variationer kan han emellertid indela de undersökta

[1] Denna temperatur erhölls vintertid i kallrum. Lägsta konstanta temperatur i termostat var 6° C.

arterna i tre grupper, som ha sina optimala zoner vid resp. höga (c:a 35 ° C), medelhöga (c:a 25 ° C) och låga (c:a 15 ° C) temperaturer. Även om man sålunda av de på maltagar utförda försöken ej kan draga några säkra slutsatser beträffande svamparnas temperaturkrav i ved, så torde man kunna säga, att de undersökta arterna i stort sett nå sin optimala utveckling vid medelhöga temperaturer (22—25 ° C.) De växa emellertid även väl vid c:a 15 ° C. och utvecklas fortfarande vid mycket låga temperaturer.

Om de yttre förhållandena i övrigt äro ogynnsamma, komma emellertid säkerligen de övre och undre gränserna att förskjutas i riktning mot optimum. Så torde exempelvis vid ogynnsam vattenhalt i virket minimum för tillväxten ligga avsevärt högre än i försöken på maltagar. Försök, som bestyrka detta antagande, ha emellertid ej blivit utförda.

C. Virkets beskaffenhet.

1) Utvecklas blånadssvamparna lättare i tall- än i granvirke? Tab. 11—13.

Det är en allmänt spridd uppfattning, att gran är mindre utsatt för blånad an tall. Vid många sågverk sågar man på grund härav under högsommaren endast det förra trädslaget. Emellertid går erfarenheten ej överallt i samma riktning. I många fall har nämligen även granen kraftigt angripits av blånadssvamparna. Man skulle på grund av dessa motsägande erfarenheter vara böjd antaga, att svamparna ej alltid förhålla sig på samma sätt gentemot sistnämnda trädslag.

Såsom en sammanfattning av resultaten beträffande våra försök över svamparnas förhållande i tall- och granvirke kan sägas följande:

Samtliga undersökta arter utvecklas mer eller mindre kraftigt i tall. Till de arter, som utvecklas hastigast på tall och orsaka en kraftig missfärgning under optimala förhållanden höra: *Ceratostomella cærulea, C. Pini, Endoconidiophora cærulescens, Sclerophoma entoxylina, Discula pinicola, Hormonema dematioides, Trichosporium tingens, Leptographium Lundbergii, Alternaria humicola* och *Xylomyces* 1. Till de i tall något mindre snabbt växande arterna kunna räknas *Ceratostomella pluriannulata, C. Piceæ, Hormodendrum cladosporioides, Cadophora fastigiata* och *Penicillium biforme.* Av dessa orsaka *Hormodendrum cladosporioides* den starkaste missfärgningen.

På vinteravverkad gran utvecklas *Endoconidiophora cærulescens* lika kraftigt som på tall eller t. o. m. kraftigare. Alla övriga undersökta blåytesvampar växa sämre i gran- än i tallvirke, även om de olika arterna därvid förhålla sig synnerligen olika.

Om man bortser från *Endoconidiophora*, utvecklas *Ceratostomella Pini, Sclerophoma entoxylina, Trichosporium tingens* bäst och orsaka en blånad, som i färgstyrka står föga efter den de åstadkomma i tallvirke. Understundom kunna dessutom *Discula pinicola, Leptographium Lundbergii* och *Xylomyces* 1 få en hastig utveckling och förorsaka en tämligen kraftig missfärgning. *Ceratostomella cærulea, C. Piceæ, Hormonema dematioides, Hormodendrum cladosporioides, Cadophora fastigiata, Alternaria humicola, Xylomyces* 1 och *Penicillium biforme* ha lämnat en obetydlig eller ingen blåyteprocent. I det förra fallet har missfärgningen i regel varit mycket svag. De två sista arterna ha aldrig orsakat blånad på gran vid laboratorieförsöken och *Ceratostomella Piceæ* har endast vid ett tillfälle (tab. 5) framkallat en svag missfärgning i de yttersta årsringarna.

I våravverkad gran ha endast *Ceratostomella cœrulea* och *Cadophora fastigiata* framkallat en ytterst svag missfärgning.

Undersökningarna ha sålunda bekräftat den uppfattningen, att gran i stort sett är ett mindre gynnsamt substrat för blåytesvamparna än tall. Men de ha å andra sidan visat, att den rätt allmänt spridda meningen, att gran överhuvud taget ej skulle anta blånad, är felaktig.

Sannolikt är det ej assimilaternas beskaffenhet, som gör granvirke i stort sett mindre gynnsamt för blåytesvamparna än tallvirke. Var den verkliga orsaken är att söka, måste tills vidare lämnas oavgjort. Det är möjligt, att parenkymcellernas protoplasma i granveden är mindre begärlig för svamparna än den i tallveden. Men det kan även tänkas, att granveden innehåller vissa för svamparna skadliga ämnen, som hämma hyfernas framträngande. Förklaringen till att vissa blåytesvampar förhålla sig tämligen nyckfullt gentemot granvirke skulle i enlighet med dessa teorier kunna ligga däri, att vissa variationer med avseende på protoplasmans karaktär förefinnas, eller att de förmodade antiseptiska ämnena understundom förekomma i större mängd än eljest.

2) Avverkningstiden och blåytesvamparnas utveckling.

Det anses ofta bland skogsmän, att det under våren och sommaren fällda timret är mera utsatt för blånad än det under vintern avverkade. Denna uppfattning träffar man ej endast i Sverige. I Nordamerika exempelvis är man allmänt av samma mening, och den gynnsammaste avverkningstiden anses även där vara höst och vinter. Våra undersökningar över denna fråga ha givit vid handen, att olikheterna i blånadens omfattning i virke med olika avverkningstid icke stå i samband med en olika näringshalt. Avgörande för det olika utfallet är fastmer olikheter i vatten resp. syrehalten i virket.

3) Blåytesvamparnas utveckling i virke med olika täthet. Tab. 19.

Det synes framgå, att åtminstone de flesta undersökta blåytesvamparna under i övrigt optimala förhållanden utvecklas hastigt även i tallvirke med stor årsringstäthet. Även om i många fall utvecklingshastigheten varit mindre i senvuxet än i frodvuxet tallvirke, har detta ej genomgående varit fallet.

Det synes oss sannolikt, att virkets täthet i och för sig ej har någon avgörande betydelse för blåytesvamparnas utvecklingshastighet. De kemiska olikheter, som ofta medfölja större olikheter i årsringstäthet torde ej heller spela någon större roll.

Blåytesvamparnas förhållande till granvirke med olika täthet har ej undersökts. Det är sannolikt, att åtminstone de arter, som utvecklas långsamt i frodvuxet virke, ytterligare hämmas eller ej alls inväxa i senvuxet sådant.

4) Svamparnas förhållande till flottat virke.

I synnerhet för brädgårdarnas vidkommande har det ett stort intresse att utröna, huruvida flottat virke i lika hög grad angripas av blåytesvamparna som färskt sådant. Den praktiska erfarenheten talar i många fall för att så ej skulle vara fallet. Några undersökningar, som bestyrka detta, ha emellertid ej blivit utförda, om man undantager dem av Malenkovič (1907) och Janka (1907). Dessa forskare konstaterade nämligen, att »urlakat» virke mindre kraftigt angreps av mögelsvampar än färskt.

Att döma av de gjorda försöken förhålla sig olika blånadssvampar olika gentemot flottat virke. En del mera känsliga arter kunna ej utvecklas i detsamma, under det att andra förorsaka en tydlig blånad. Av de senare

synas några (ex. *Ceratostomella cærulea*) växa långsammare i flottat än i icke flottat virke, andra däremot utvecklas ungefär lika kraftigt i bådadera. Till de senare höra *Hormonema dematioides, Cadophora fastigiata,* båda vanliga i brädgårdar.

Orsakerna till att det flottade virket för flera arter varit synnerligen ogynnsamt äro säkerligen flera. En del för svamparna viktiga salter och andra näringsämnen ha givetvis decimerats, dels direkt genom urlakning, dels indirekt genom mikroorganismers verksamhet, varigenom virkets näringsvärde för svamparna sjunkit. Dessutom ha sannolikt genom de mikroorganismer — framför allt bakterier — som levat på virkets yta och i dess inre, vissa toxiska ämnen bildats, som hindrat eller försvårat en del blåytesvampars inträngande.

Sammanfattning.

1. Våra undersökningar ha visat, att de flesta, praktisk betydelsefulla blånadssvamparna tillhöra sphæropsideer och hyphomyceter. Den roll, som man tidigare allmänt tillskrivit arter av fam. *Ceratostomataceæ* (*Ceratostomella*- och *Endoconidiophora*-arter), har uppenbarligen överskattats.

2. Av egentliga blåytesvampar ha vi isolerat och närmare prövat 16 arter och former, av vilka 5 tillhöra fam. *Ceratostomataceæ,* 3 äro sphæropsideer och 8 hyphomyceter. Dessutom har ur virke isolerats en *Penicillium*-art, vilken tack vare en riklig konidiealstring inuti veden även kan framkalla en tydlig blånad.

3. Som svenska blåytesvampar, tillhörande fam. *Ceratostomataceæ,* ha vi påvisat följande arter: *Ceratostomella cærulea* Münch, *C. Piceæ* Münch, *C. pluriannulata* Hedgcock, *C. Pini* Münch samt *Endoconidiophora cærulescens* Münch. Av dessa är *C. pluriannulata* tidigare endast angiven för Nordamerika.

4. Bland sphæropsideerna äro representerade släktena *Discula* och *Sclerophoma,* det förra genom *D. pinicola* (Naumow) Petrak och den av oss urskilda var. *mammosa,* det senare genom *S. entoxylina* n. sp. *D. pinicola,* nyligen beskriven från Ryssland, är förut icke känd som blåytesvamp.

5. Av de undersökta hyphomyceterna ha vi ansett oss böra uppställa 3 former som typer för nya släkten, nämligen *Hormonema dematioides* nov. gen. et sp. (= »*Dematium pullulans*» de Bary et Löw), *Leptographium Lundbergii* nov. gen. et sp. och *Cadophora fastigiata* nov. gen. et sp. Bland de övriga ha nybeskrivits *Trichosporium tingens* och *Hormodendrum microsporum.* Den som humussvamp kända *Alternaria humicola* Oudemans tillhör även blånadssvamparna. Detsamma gäller om *Hormodendrum cladosporioides* samt om ett sterilt mycel, som vi provisoriskt benämnt *Xylomyces* 1, och som sannolikt är att hänföra till hyphomyceterna.

6. Av hyphomyceterna äro sådana arter som *Hormonema dematioides* och *Hormodendrum cladosporioides* ytterst vanliga bl. a. på levande blad och andra växtdelar — båda ingå nästan undantagslöst som konstituenter i s. k. sotdagg.

7. De flesta blånadssvampar leva så gott som uteslusande i splintens parenkymatiska vävnader (en del, t. ex. *Endoconidiophora cærulescens* och *Leptographium Lundbergii,* visar dock stor benägenhet att samtidigt växa längs genom trakeiderna). Som bekant blir därför den som blånad betecknade missfärgningen praktiskt taget begränsad till splintved. Våra undersökningar

ha emellertid ådagalagt, att även en fullt typisk kärnblånad förekommer (framkallad t. ex. genom *Hormodendrum microsporum*). I den senare visa hyferna icke någon speciell dragning till vedens märgstrålar och hartsgångar.

8. Beträffande detaljerna i mycelets utbildning i veden föreligga i övrigt så stora skiljaktigheter mellan olika svamparter, att flera, väl karakteriserade typer kunna uppställas. Detta gäller exempelvis förmåga till konidiebildning inuti veden och hyfernas sätt att genomtränga trakeidmembranerna. En fullt säker artbestämning enbart med ledning av mycelets växtformer är dock i allmänhet icke möjlig. Ett undantag härutinnan bildar *Hormonema dematioides*.

9. De flesta arterna ha experimentellt prövats med hänsyn till sina krav på vatten- och syrehalt i virket ävensom beträffande tillväxthastighetens beroende av temperaturen. Dessutom har undersökts den inverkan, som i varje särskilt fall virkets specifika kvalitet utövar på svamparnas blånande förmåga.

10. Beträffande svamparnas utvecklingshastighet i virke med samma vattenhalt föreligger en påtaglig skillnad, då de få växa i paraffinerade och icke paraffinerade sektorer. Denna omständighet förklaras därav, att syre under försökets gång inträngер långsammare i det förra än i det senare materialet. Svamparnas utvecklingsmöjligheter i en paraffinerad sektor motsvaras närmast av dem, som i naturen erbjudas dem i rundvirke, och den oparaffinerade sektorn kan närmast jämställas med den sågade varan.

11. Den vattenhalt, som normalt förekommer i vinteravverkat virke, medger icke någon eller i alla händelser en ytterst obetydlig blånadsbildning, beroende på för ringa syretillgång. I ej paraffinerade sektorer från sådant virke har dock en vattenförlust av c:a 10 % varit tillräcklig, för att svamparna skulle nå sitt utvecklingsoptimum. I de sektorer, som paraffinerades, måste dock först en vattenminskning av 60—80 % åstadkommas, för att detta optimum skulle uppnås. I det förra fallet visa svamparna en mycket bred, optimal tillväxtzon, i det senare är optimum starkt begränsat, vilket beror på en olika livlig luftväxling under försökets gång. En undantagsställning härutinnan intar framför allt *Ceratostomella Pini*, som växt lika kraftigt, oberoende av sektorernas behandling.

12. Av försöken måste den slutsatsen dragas, att olika blånadssvampar ha olika syrekrav. Till de mest syrebehövande höra *Discula pinicola* och *Trichosporium tingens*, till de minst fordrande *Hormonema dematioides* och *Ceratostomella Pini*.

13. Sedan blånadsmaximum uppnåtts, är den för hyferna tillgängliga vattenmängden avgörande för deras tillväxtintensitet. Vid en vattenhalt, som närmar sig fibermättningspunkten (c:a 30 % av torrsubstansen), ha svamparna icke längre förmåga att missfärga virket. För en del arter ligger dock den undre gränsen högre än för den andra.

14. I virke med sekundärt, fritt vatten utvecklas en del arter (t. ex. *Endoconidiophora cærulescens*) alls icke, andra ytterst svagt (t. ex. *Ceratostomella cærulea*). För hyphomyceterna och de undersökta sphæropsideerna spelar denna faktor en mindre framträdande roll.

15. För fastställandet av svamparnas temperaturkrav ha agarkulturer använts. Optimum ligger i allmänhet vid omkring + 22° C. Den nedre gränsen torde ligga omedelbart ovan nollpunkten.

16. Granvirke är i stort sett ett mindre gynnsamt substrat för blåytesvamparna än tallvirke. En viss nyckfullhet har emellertid härutinnan gjort

sig gällande, i det att vissa arter understundom angripit tämligen kraftigt, i andra fall däremot alls icke.

17. Vår- och sommaravverkat virke är från näringssynpunkt ej gynnsammare för blåytesvamparna än vinteravverkat. Beträffande granen synes snarare det motsatta förhållandet äga rum. Om sommaravverkat tallvirke mera utsättes för blånad än vinteravverkat, som lagrats så, att vattenavgivning förhindrats, så är orsaken härtill den, att vatten- resp. syrehalten varit gynnsammare för svamparna i det förstnämnda fallet.

18. Under sommaren sjunker vattenhalten till följd av trädens transpiration — i synnerhet hos gran — så starkt, att möjlighet föreligger för vissa svamparter att inträngа i de levande stammarna, där veden blottats. Ett exempel härpå utgör den s. k. stämplingsblånaden hos gran, förorsakad av *Endoconidiophora cœrulescens* och *Discula pinicola*.

19. Svamparnas förhållande till tallvirke av olika täthet har undersökts. Det har därvid framgått, att åtminstone de flesta arter under i övrigt optimala förhållanden utvecklas hastigt även i virke av stor årsringstäthet. Även om i många fall svamparnas tillväxthastighet varit mindre i senvuxet än i frodvuxet tallvirke, har dock detta icke varit genomgående. Svamparnas förhållande till granvirke av olika täthet har ej prövats.

20. Till flottat virke förhålla sig olika svampar väsentligen olika. De mera känsliga arterna kunna icke utvecklas i detsamma, medan andra här framkalla en tydlig blånad. Av de senare växa några långsammare i flottat än i oflottat virke, andra däremot ungefär lika kraftigt i bådadera. Till dem höra *Hormonema dematioides* och *Cadophora fastigiata*, vilka också tillhöra brädgårdarnas vanligaste blåytesvampar.

II. LAGRINGSFÖRSÖK MED RUNDVIRKE.

Lagring av rundvirke kan avse högst olika ändamål. Timmer kan vid verk och fabriker behöva lagras i avvaktan på upparbetning eller i skogen i avvaktan på utdrivningsföre. Det enda intresset är då, att det under lagringstiden på bästa möjliga sätt skyddas mot skador.

I andra fall såsom beträffande rundvirke, som före upparbetningen måste vara torrt, som skall flottas och först efter uttorkning kan bibringas nödig flytförmåga, eller som av rena fraktkostnadsskäl önskas uttorkat före uttransporten ur skogen, får lagringen däremot till huvudändamål att åstadkomma dylik uttorkning och att få densamma genomförd med minsta möjliga skador.

På denna grund ha vi planlagt våra försöksserier efter två skilda linjer, den ena med grövre dimensioner — sågtimmer — och avseende att utröna lämpligaste lagringsform för sådant virke, som kan behöva lagras över någon kortare period — högst ett år — utan hänsyn till uttorkning och den andra med pappersmassaved, avseende virke, som man önskar uttorka genom lagring.

Den förra serien ha vi kallat timmerlagring och den senare massavedslagring, oberoende av att slutsatserna från dessa försöksserier självfallet ej äro bundna till dessa sortimentstyper, liksom att sortimenten i fråga själva i praktiken kunna lagras med olika inriktning.

1. Timmerlagringen.

Planläggning och genomförande. Då man förut känner, att virkesmagasinering i vatten bäst skyddar för skador, men långt ifrån alltid är möj-

lig att åstadkomma, begränsades försöken till landmagasinering genom uppläggning av ett antal försöksvältor spännande över praktiskt tänkbara lagringsformer från den mest uttorkande å ena sidan till den mest fuktighetsbevarande å den andra.

Följande försökstyper anordnades, nedan grupperade i ordning från de torrare till de fuktigare uppläggningsformerna:

Välta N:o 1 och 2. Helbarkat timmer, upplagt i korsdragen välta, i öppet läge å mindre hygge, vältan utan betäckning.
» » 3 och 4. Helbarkat timmer, klosslagd, obetäckt välta i skuggigt läge i äldre barrblandbestånd.
» » 5 och 6. Helbarkat timmer, klosslagd välta i skuggigt läge. Vältan täckt med granris.
» » 7 och 8. Obarkat timmer, upplagt i korsdragen, obetäckt välta i öppet och fritt läge.
» » 9 och 10. Obarkat timmer, upplagt i klosslagd, obetäckt välta i skuggigt läge.
» » 11 och 12. Obarkat timmer (vältan N:o 11 dock för inmätning av timret genom förbiseende toppbarkat till c:a en fots längd) upplagt i klosslagd välta direkt å avplanad mark i skuggigt läge. Vältan täckt med ett tjockt lager av granris.
» » 13 och 14. Obarkat timmer (i vältan N:o 13 voro dock några stockar genom förbiseende toppbarkade) hoplagt i klosslagd välta, direkt å avplanad mark — vältan N:o 13 i kärrkant — men båda i skuggigt läge och fullständigt täckta med ett lager av mossa, förna och skogstorv.

För att utröna i vad mån virke, som avverkats under midvintern, vore olika mottagligt för lagringsskador i förhållande till sådant, som avverkats längre fram mot våren, och för att samtidigt erhålla större kontrollmöjligheter över försöken lades dubbla vältor av varje omförmäld typ därav den ena (alla vältor med udda nummer) omfattade virke, som avverkats i början av januari 1923 och den andra (alla vältor med jämnt nummer) virke, som avverkats under senare delen av mars eller början av april samma år.

Varje välta omfattade c:a 100 sågtimmerstockar, omkring 60 % tall och 40 % gran, blandade om varandra, så som fallet blir i en vanlig timmervälta. Sågtimret härrörde från c:a 100-årigt bestånd på medelgod moränmark. Timrets volymvikt, kärnhalt m. m. framgår närmare av tab. 21.

Under tiden 4—10 april, ungefär vid tiden för snösmältningen, anlades och täcktes vältorna på angivet sätt. Deras omfattning och utseende framgå jämväl av fig. 87 och 88.

Sedan vältorna på angivet sätt iordningställts, fingo de ligga i orubbat skick över sommaren och ända ut i november, då vintern bröt in och den egentliga revisionen tog vid. Dock gjordes ytliga undersökningar under sommarens lopp, rörande blåytans uppträdande och konstaterades därvid de första påtagliga blåyteangreppen å de helbarkade vältorna omkring 15 juli, vilka sedan successivt ökades under sommarens lopp. Å barkskadade eller barkfria partier å stockar i övriga vältor gjordes samma iakttagelse.

Vid vältornas uppbrytning och revidering, som ägde rum i mitten av no-

vember, vägdes stockarna på nytt för bestämmande av den uttorkning eller viktsförändring, som virket under lagringstiden undergått.

Dessa så konstaterade viktsförändringar framgå av tabell 21, varav man finner att avsevärdare uttorkning endast ägt rum beträffande vältorna 1—4, d. v. s. de som omfattade helbarkat, obetäckt virke, där uttorkningen varierat mellan 24—33 % av ursprungsvikten. Uttorkningen i vältorna 5—10 är som synes relativt obetydlig, varierande mellan 1—6 % av ursprungsvikten, d. v. s. såväl för helbarkade, ristäckta vältor som för obarkade, obetäckta. I de obarkade och täckta vältorna 11—14 har däremot timret alls icke torkat utan fastmera tyngt eller ökat i vikt från 1—8 %. Till en del torde dock denna viktsökning vara att hänföra till vidhäftande fuktighet i form av vid barken fastfrusen is.

Bland övriga observationer vid vältornas rivning må följande framhållas: I de obarkade torvtäckta vältorna var timrets bark, där den ej särskilt utsatts för yttre skador, ännu levande och veden därunder fullständigt frisk som i ett ännu levande träd. Barken å samtliga stockar var emellertid helt överspunnen av vita mycelsträngar och en rötbildning hade börjat i veden på nästan alla sådana ställen, där barken genom åverkan eller eljest avlägsnats, liksom ock, ehuru ej i nämnvärd mån, genom stockarnas ändsnittytor.

Som ovan framhållits, hade en del av det obarkade timret i de torvtäckta vältorna av misstag blivit för inmätning barkade i toppändan. Dessa avbarkade ändar visade sig starkt angripna av lagringsröta *(Stereum sanguinolentum)*, vilket förklarar, att resultatet av lagringen i dessa vältor vid den objektiva undersökningen å sågverksutfallet ej gav så gynnsamt utslag, som man vid den första okulära besiktningen kunde förvänta, då timret i huvudsak verkade friskt och oskadat.

Ä det i obetäckta vältor inlagda, helbarkade timret hade under högsommaren observerats rätt avsevärda sprickor i de ytligare lagren av vältan. Dessa sprickor voro emellertid vid revisionen i november fullt osynliga, då de ånyo slutit sig.

För att få ett fullt objektivt uttryck såväl för skadornas omfattning i det på olika sätt lagrade timret, som ock ett uttryck för dessa skadors ekonomiska inverkan på sågutbytet kördes under vintern timret till Garpenbergs sågverk, varest det i februari försågades och därvid närmare undersöktes.

Vid försågningen postades samtliga förekommande timmerdimensioner på enahanda sätt, nämligen så, att märgen klövs och på vardera sidan om mittskäret uttogs först en 2″ tjock battensdimension och därutanför 1″ bräder. Före sågutbytets kantning bestämdes blåyte- och rötskadors frekvens dels på inre sidan av vänstra 2″ dimensionen och dels på yttre sidan av första högra 1″ dimensionen. Vid skadornas bestämmande särskildes såväl lagringsröta som blåyta i tre klasser eller styrkegrader. Den svagaste formen utgjordes av svag ljusblå färgning eller ljus brunfärgning genom lagringsröta, respektive betecknade med b och r, medan däremot till den svåraste formen hänfördes mörk blåyta och helt brunfärgad lagringsröta, respektive betecknade med *b* och *r*. Mellan dessa starkt markerade ytterlägen särskildes därtill ett mellanläge betecknat med resp. *b* och *r* för blåyte- och rötskador.

Bestämningen av skadorna skedde å provlinjer, som förlades tvärs över plankorna, på ett inbördes avstånd av 2 fot. I tabellerna 22—25 finnas skadorna sålunda angivna i % av plankans yta.

Vid försågningstillfället kunde några sprickor ej upptäckas, på grund av att dylika eventuellt befintliga genom timrets fuktiga beskaffenhet under vintern ånyo slutits. Revision av sprickförekomst uppsköts därför till framåt början av juni då sågutbytet, som under tiden behörigen etiketterat legat staplat i brädgårdsstaplar på vanligt sätt under skyddande tak, ånyo närmare undersöktes.

För att erhålla ett objektivt uttryck för sprickförekomsten tillvägagicks på följande sätt.

Sprickorna undersöktes å på varannan fot förlagda tvärundersökningslinjer å plankornas eller brädernas ena sida och ena kant. Sidornas (plattornas) sprickor särskildes härvid i tre klasser, fina sprickor betecknade med cs som voro under 1 mm i bredd och ej genomgående, medelgrova *cs* över 1 mm breda helt öppna men ej genomgående, samt grova sprickor ***cs***, i huvudsak genomgående eller mycket breda. Kantsprickorna sammanfördes i en klass och betecknades med ce.

För att få ett objektivt uttryck för sprickförekomsten å de olika dimensionerna sattes antalet av de skilda slagen sprickor i direkt förhållande till 100 tum undersökt eller taxerad linje.

I sammandrag framgår sprickförekomsten av tab. 26. Då sågutbytet genom lagringen nått full skeppningstorrhet, eller samtidigt med revideringen av sprickförekomsten i juni, sorterades detsamma enligt vanlig sorteringskutym i 6 klasser för ett närmare fastställande av lagringsskadornas ekonomiska inverkan.

Vid denna sortering, som skedde av van sorterare, sågverksförmannen vid Garpenbergs såg, bortsågs emellertid från tillverkningsfel och andra skador på virket än rena lagringsskador, d. v. s. sorteringen skedde endast med hänsyn till förekomsten av blåyta, rötfärgning eller sprickor, utan vilka fel virket i och för sig vore att betrakta som av högsta klass.

Resultatet av denna sortering och sågutbytets från resp. lagringsformer fördelning på olika kvalitetsklasser framgår av tabellerna 27—30.

Efter samråd med Svenska Trävaruexportföreningen fastställdes det relativa värdet mellan de olika sortklasserna sågat virke sålunda:

värdet	å	I	sort	lika	med	100 %
»	»	II	»	»	»	77.5 %
»	»	III	»	»	»	65 %
»	»	IV	»	»	»	60 %
»	»	V	»	»	»	50 %
»	»	VI	»	»	»	37.5 %

Splittveden har för enkelhetens skull beräknats i värde lika med VI sort eller till 37.5 % av värdet å I sort.

Tillämpas nu dessa relativa värden på procentutfallet av olika sortklasser i tab. 27—30 och hopsummeras resultatet, erhålles ett uttryck för utfallets relativa värde i förhållande till det värde oskadat virke av högsta kvalitet besitter.

Skillnaden mellan detta senare värde och det som på grund av lagringsskador kunnat erhållas, eller värdeminskningen genom lagringen framgår av tab. 31.

Anmärkas bör alltså att denna i tabellen upptagna värdeminskning är att anse som ett maximaluttryck för den inverkan lagringsskadorna kunnat få, om virket i övrigt varit av högsta kvalitet d. v. s. I sort, vilket i verkligheten naturligtvis ej kan bli fallet.

Reflexioner över de erhållna resultaten.

Insektsskador av inverkan på sågutbytets kvalitet ha ej vid någon lagringsform framträtt.

Sprickbildning genom lagringen har endast i nämnvärd grad förekommit vid de allra torraste lagringsformerna och endast beträffande helbarkat virke i obetäckta vältor fått någon ekonomisk inverkan.

Blåyta och lagringsröta äro de skador, som mest inverkat på timrets värdesänkning.

Båda dessa skadors frekvens och kvalitativa omfattning visa sig påtagligt störst i de torraste lagringsformerna och avta successivt mot de fuktigare för att nå sitt minimum i de obarkade, torvtäckta vältorna, där de praktiskt taget skulle saknats, om ej en del timmer varit barkskadat eller toppbarkat. Minst äro dessa skador i vältan N:o 13, som var belägen direkt på fuktig kärrmark.

Någon påvisbar skillnad i frekvensen av blånadsskador å det virke, som avverkats under midvintern och på våren, framträder ej och bekräftar sålunda de resultat i samma riktning, som framgått av laboratorieförsöken och som ovan framlagts.

Då de grova timmerstockarna även genom den luftigaste lagring ej kunna nå en sådan uttorkning, som hindrar blåytesvamparnas utveckling, men väl genom en luftig lagringsform nå en torrhetsgrad, som befrämjar eller gynnar blåytesvamparnas utveckling, är det jämväl i full överensstämmelse med de slutsatser vi av laboratorieförsöken kunnat draga, att blånaden blivit mest betydande i de luftigt upplagda vältorna eller de torraste lagringsformerna.

Att däremot även lagringsrötan blivit mera betydande i det helbarkade virket under öppna och luftiga lagringsformer än i det obarkade under fuktigare lagringsformer kan kanske vid första påseende vara ägnat att förvåna. Dessa svampars fuktighetskrav äro nämligen relativt höga och det färska virkets fuktighetshalt utgör i och sig intet hinder för deras utveckling.

Det berörda förhållandet får emellertid sin förklaring genom sprickbildningen. De relativt grova sågtimmerstockarna hinna ej ens vid luftigaste lagring uttorka så fullständigt, att minimifuktighetshalten för lagringsrötorna nås. Genom de sprickor, som efter en torkperiod uppkomma, blir stocken på en gång infekterad med svampsporer långt in i veden. När dessa sprickor vid fuktigare väderlek fyllas med vatten eller tillslutas, gro sporerna och dessa stockar bli alltså grundligare infekterade och angripna än sådana, som ospruckna endast kunna utsättas för mera ytlig infektion.

Om man jämför dessa erfarenheter rörande lagringsrötan med dem, vilka framgått av Lagerbergs (1924) lagringsförsök med sulfitved liksom med dem vi framdeles komma att beröra i samband med redogörelsen för massavedslagringen, kan måhända vid första påseendet en viss motsättning frappera, då i dessa fall endast de torrare lagringsformerna varit ägnade att skydda virket mot lagringsröta. Det bör dock härvid observeras, att Lagerbergs försök liksom våra försök med massavedslagringen beröra klenare dimensioner,

som fortare genomtorka, varjämte den ovan skildrade sågtimmerlagringen endast sträcker sig över en sommar.

Skulle sågtimret kvarlagras under längre tid, skulle förhållandena därjämte snart utvecklas till det omvända eller samma, som framkommit vid LAGERBERGS sulfitvedlagringsförsök, som spänner över längre tid. D. v. s. under ett kommande lagringsår skulle de fuktigt lagrade timmervältorna helt komma att genomsättas av lagringsröta, medan däremot de torrare lagringsformerna skulle komma att visa mindre betydande förändring till det sämre.

Denna slutsats kan man utan vidare draga av det förhållandet, att vältorna av fuktigare lagringstyp voro helt genomspunna med svampmycel, som endast av den ännu levande barken hindrades att inträngа i veden, medan däremot de barkskadade partierna å stockar i dylika vältor häftigt angripits redan under första lagringsåret.

De ovan omnämnda sågtimmervältornas medeldiameter torde legat omkring 22 cm. För att dels studera randbarknings inverkan på lagringsskadorna, dels inverkan av klenare dimensioner, som lättare genomtorka vid luftigare uppläggning, avlades parallellt med ovan omnämnda sågtimmervältor ett antal av randbarkad massaved om tre meters längd och av en medeldiameter på mitt av c:a 14.5 cm (se tab. 32). Vältorna omfattade vardera 100 stockar, därav c:a 60 % tall och 40 % gran hopblandade i samma välta. Tre olika välttyper användes, nämligen strölagd, obetäckt välta i öppet läge, klosslagd obetäckt i mera skuggigt läge samt klosslagd risbetäckt i skuggigt läge. Av vardera typen lades tvenne vältor (jämför tab. 32), varav den ena omfattade virke, som avverkats under midvintern och den andra virke avverkat i slutet av mars. Vältorna iordningställdes under senare delen av mars och början av april och fingo sedan ligga orubbade till 15 november, då de reviderades.

Vid denna revision vägdes ånyo samtliga stockar för fastställandet av viktsförändringarna, varjämte var tionde stock uttogs för närmare analys av lagringsskadorna. Dessa skador bestämdes sålunda, att från varje klamp togs en trissa på mitten och en c:a en fot från klampens grövre ända. På dessa skivor bestämdes skadornas omfattning genom planimetrering, varvid liksom beträffande sågtimret särskildes tre valörer av blåyta och tre av lagringsröta, resp. betecknade med b, *b*, ***b*** och r, *r*, ***r*** och dessas summor med resp. B. och R. (se tab. 32). Medeltalet för skadornas omfattning i hela klampen är beräknat sålunda, att trissan som togs en fot från grövre ändan, fått väga dubbelt mot mitt-trissan.

Resultatet av revisionen framgår av tab. 32. Man ser därav, att skillnaden i uttorkning mellan de strölagda obetäckta vältorna, som lättat från 23—31 % av sin ursprungsvikt, är betydande i förhållande till de risbetäckta klosslagda, som endast lättat 3,5—7,5 % av sin ursprungsvikt. De klosslagda obetäckta vältorna ha, sannolikt beroende av vedens korta längd 3 m, torkat relativt bra, om än givetvis mindre än de strölagda, eller 20—23 % viktminskning.

Studerar man vidare skadornas omfattning finner man, att granen i de luftiga, strölagda vältorna praktiskt taget är i det närmaste fri från skador såväl av blånad som lagringsröta (varav dock i den ena vältan förekommer 8,77 % skador företrädesvis dock av lindrigare art), ävensom att granen i nästan alla lagringsformerna blivit fri från blåyta. I de båda fuktigare lagringsformerna, såväl klosslagd obetäckt som klosslagd risbetäckt välta, ha däremot lagringsrötorna vållat betydande angrepp på granen (18—60 % av vedens massa).

Tallvirket visar sig även i dessa vältor avsevärt mera utsatt såväl för blåyteskador som lagringsröta, och vad som härvid mest är ägnat att frappera är det förhållandet, att tallvirket även i den luftigaste lagringsformen (strölagd obetäckt välta) starkt angripits av lagringsröta (46 resp. 47 % av vedens massa). De fuktigare lagringsformerna giva dock även för tallen större procent skador av lagringsröta, medan däremot blåytan tycks vara ungefär lika omfattande i alla tre lagringsformerna, lägst 7 och högst 19 % av stockarnas totala massa. Resultatet av denna undersökningsserie kan alltså sägas gå i fullständigt samma riktning som LAGERBERGS (1924).

Väderleken under försöksåret var ej för försökstrakten fullt normal, i det att den särskilt under förra delen av sommaren var något kallare och regnigare än normalt. Av fig. 89—91 framgå medeltemperatur, medelnederbörd och relativ medelfuktighet uttryckt i % av full mättningsgrad för Falun (närmaste meteorologiska försöksstation) ävensom för 1923, samt av fig. 92 och 93 temperatur- och nederbördsförhållanden för åren 1924 och 1925.

På grund av väderleksförhållandenas något onormala beskaffenhet under 1923 ävensom i avsikt att vinna ytterligare bekräftelse på riktigheten av de under 1923 erhållna resultaten upprepades under 1924 försöken med sågtimmerlagring i torvtäckta vältor, vilka försök utfördes av jägmästare ENANDER vid Garpenberg enligt samma förfaringssätt som under 1923, men med det tillägg, att i vissa vältor koksalt inströddes mellan timmervarven i de torvtäckta vältorna för att minska möjligheten för rötsvampmycelets utveckling.

Resultatet av dessa jägmästare ENANDERS försök under 1924 blev fullt analogt med det, som erhölls under 1923, om än skadorna i de torvtäckta vältorna i vilka ej inströning av koksalt förekommit, blevo en aning mera betydande än under 1923, vilket närmast får sin förklaring därav, att vältorna under 1924 endast voro hälften så stora som 1923. Det visade sig nämligen såväl 1923 som 1924, att i de torvtäckta vältorna skadorna i de övre delarna av vältan voro mest betydande, medan däremot de undre skikten voro minst angripna.

Beträffande inströningen av koksalt i vissa av de torvtäckta vältorna 1924 visade sig resultatet härav tämligen obetydligt och av påtagligt gynnsam effekt endast beträffande talltimret. Koksalt torde i och för sig vara ett för svagt och alltför lätturlakbart gift för att skydda vältorna mot rötsvampmycelens utveckling.

Avsevärt effektivare torde vara att direkt bestryka de från bark blottade ytorna å timret i de torvtäckta vältorna med något impregneringsmedel av mera effektiv art.

Sammanfattning av timmerlagringens praktiska resultat.

På grund av ovan framhållna försöksresultat kan som sammanfattning följande råd lämnas, rörande lämpligaste behandling av timmer, som man ej har möjlighet att magasinera i vatten, och som på bästa sätt skall skyddas mot lagringsskador över endast en sommar utan att uttorkning i och för sig särskilt eftersträvas:

1) Är timret ej redan barkat, bör barken under alla omständigheter bibehållas, då densamma under första sommarens lagring är ett betydelsefullt skydd både mot blåyteskador och rötsvampar.

2) Det obarkade sågtimret bör hopdragas i så stora vältor som möjligt, vilka klossläggas direkt å den avplanade, fuktiga marken, helst i skuggigt läge. Är barken hel å timret, d. v. s. har ej ens toppbarkning skett eller barken vid hopsläpningen av timret avsevärt skadats, bevaras timret än bättre om dessa vältor ytterligare täckas med ris, torv eller förna.

Rörande torvtäckta vältors läggning förtjäna följande detaljer särskilt framhållas: Det är av stor betydelse att vältorna göras så stora som möjligt, att de läggas i kalla, skuggiga och ej i varma lägen, att hopläggningen sker så tidigt som möjligt på våren, helst medan snö och is ännu finnas kvar, så att kylan i största möjliga grad bibehålles i vältan. Koksaltinströning minskar sannolikt i någon mån risken för rötangrepp å avbarkade vedpartier, men är ej något effektivare skyddsmedel, varför bästa sättet att skydda dylika avbarkade partier torde vara bestrykning med effektivare impregneringsmedel.

3) Är timret åter toppbarkat eller i avsevärd grad barkskadat vid hopsläpningen, torde de upplagda timmervältorna ej böra täckas med torv eller tätare täcke annat än i det fall bestrykning av blottade vedytor ägt rum med något impregneringsmedel. I stället täckas vältorna med tunnare granrisskikt.

4) Är timret redan helbarkat, skyddas detsamma bäst genom uppläggning i täta klosslagda vältor så stora som möjligt, å skuggig plats, varjämte granristäckning är att förorda.

5) Är timret av mycket klena dimensioner, mindre än ordinärt sågtimmer, eller av c:a 15 cm eller lägre diameter och är detsamma redan barkat, torde dock sannolikt en luftigare lagringsform i strölagda mindre vältor i öppna lägen ge minsta lagringsskadorna. Detta gäller särskilt gran, som vid dylik lagring tämligen effektivt skyddas.

Anmärkas bör slutligen att tall under alla lagringsformer är avsevärt mera utsatt för lagringsskador än gran, varför man, där så ske kan i första hand bör undvika överlagring av tallvirket.

Avverkningstiden, d. v. s. om avverkning skett under midvintern eller på eftervintern, synes däremot ej ha inverkan på lagringsskadornas uppträdande.

Att det däremot är av största vikt, att det sågtimmer, som enligt ovan framhållna principer överlagrats under en sommar, under den därpå kommande vintern utdrives och fortast möjligt försågas behöver väl knappast framhållas.

En förlängd lagring av timret under någon del av nästpåföljande sommar kommer att medföra en väsentlig stegring av lagringsskadorna och framför allt torde då lagringsrötan i de fuktigare lagringsformerna bli katastrofal.

2. Massavedslagringen.

Dessa försök, vilka likaledes anordnades vid Garpenberg 1923, gingo närmast ut på att undersöka, vilken inverkan avverkningstid, uppläggningsform och behandling av virket kunna ha på torkningsresultat och lagringsskador vid uppläggning av virket i skogen, direkt vid avverkningsplatsen, eller på sätt, som vid praktisk avverkning kan ifrågakomma.

Det för lagringsförsöken avsedda virket uttogs i normalslutet, växtligt c:a 50-årigt blandbestånd av tall och gran på frisk moränmark.

Klamparna upphöggos i lika längder, 3 m, och voro av en diameter varierande mellan 10—18 (20) cm eller av de dimensioner, som för ordinär massaved bruka ifrågakomma.

Avverkning, behandling av virket och dess uppläggning på olika sätt skedde samtidigt. Den första försöksserien avverkades den 10 april, den andra den 15 april och därefter den 1 och 15 i varje månad till och med den första oktober, då sista avläggningen ägde rum.

Vid varje avverkningstillfälle upphöggs 60 st. klampar, hälften av tall och hälften av gran. Tjugu av klamparna helbarkades, tjugu randbarkades, och tjugu lämnades obarkade. Av varje behandlingsform upplades sedan hälften av klamparna i luftiga s. k. triangelklipp (stockarna korslagda i triangelform över varandra), medan den andra hälften lades i en liten hög eller välta direkt på marken. All upplagring skedde inne i det normalt slutna men nygallrade beståndet på frisk markbotten.

Vid varje avläggnings-avverkningstillfälle fingo vi alltså 6 olika upplagstyper med 10 klampar i varje, därav 5 av tall och 5 av gran, nämligen:

1) Helbarkat virke upplagt i luftiga trianglar.
2) D:o d:o direkt på marken.
3) Randbarkat virke upplagt i luftiga trianglar.
4) D:o d:o direkt på marken.
5) Obarkat virke upplagt i luftiga trianglar.
6) D:o d:o direkt på marken.

Vid avverkningstillfället vägdes samtliga klampar och därefter varje 1 och 15 i påföljande månader till och med den 1 oktober, varefter en sista vägning ägde rum vid revisionen av försöken, som ägde rum med början den 16 november 1923, sedan vintern med kyla och snö inbrutit.

Resultatet av dessa vägningar framgår av tabellerna 33—38, å vilka viktförändringarna för samtliga avläggningar angivits i procent av ursprungsvikterna. Studeras viktförändringarnas förlopp och slutresultatet å dessa tabeller, framgå följande förhållanden.

1) Det helbarkade virket, upplagt i trianglar, har som man kunnat vänta torkat bäst, och anmärkningsvärt är att torkningen varit god och betydande å allt virke, som avverkats ännu så sent som 15 juli.

2) Det helbarkade direkt på marken lagrade virket, som avverkats 15 juni och tidigare, synes ha torkat ungefär lika bra som det i trianglar upplagda. Efter 1 juli avverkat har emellertid torkat mera obetydligt, och allt som avverkats 1 augusti och senare har ökat i vikt.

3) Det randbarkade i triangel upplagda virket har genomgående torkat avsevärt bättre än lika behandlat på marken direkt lagrat. Det 1 juli och tidigare avverkade har torkat obetydligt sämre än det lika lagrade men helbarkade, till och med avverkningen den 15 juli har givit rätt god torkning, men det som avverkats 1 sept. eller senare har ej torkat utan ökat något i vikt.

4) Det randbarkade på marken lagrade virket har torkat mera obetydligt, och allt dylikt virke, som avverkats 15 juli och senare har ökat i vikt.

5) Det obarkade i triangel lagrade virket har torkat mycket obetydligt och allt, som avverkats 15 juli och senare, har ökat i vikt.

6) Det obarkade på marken lagrade virket har endast beträffande gran visat någon, om än ringa torkning som resultat av lagringen och då endast beträffande sådan gran, som avverkats 15 juli och tidigare.

All tall samt gran avverkad 1 juli och senare har ökat i vikt.

Granen har i stort sett genomgående torkat eller lättat mera i vikt än tallen i samtliga avläggningsformer, och av viktminskningsserierna tycks även

framgå, att detta har sin grund i det förut kända förhållandet, att tall vid fuktig väderlek lättare ånyo tar upp vatten än gran.

För att få någon uppfattning om verkliga vattenhalten vid lagringstidens slut uttogs ur varje avläggning en provklamp av gran och en av tall för närmare fuktighetsbestämning. Dessa provklampar uttogos från mitten av trianglarna resp. de på marken liggande högarna, eller närmare bestämt valdes klampar av medeldimension så nära mitten som möjligt av varje upplag.

Från varje sådan klamp uttogs två tvärtrissor, en belägen c:a en fot innanför grovändan av klampen, i tabellerna benämnd »rotsektion» och en vid klampens mitt, »mittsektion». Vattenhalten i dessa prov, angiven i procent av torrsubstansvikten, framgår av tabellernas båda sista kolumner.

Då dessa tal emellertid i motsats till viktminskningssiffrorna framtagits på en enda klamp av varje trädslag i vältan eller triangeln, få desamma ej tillmätas alltför stort värde, då fuktigheten givetvis växlar inom olika klampar i samma avlägg.

Lagringsskadorna på försöksmaterialet — lagringsröta och blåyta — bestämdes vid revisionen av försöken under november på följande sätt.

Från varje klamp utsågades två trissor, en på mitten och en c:a en fot från grovändan. På dessa stamskivor utmärktes de skadade partierna, som allt efter skadans art särskildes i blåyta i tre styrkegrader, i tablåerna betecknade med b, *b* och ***b*** samt lagringsröta i likaledes tre styrkegrader r, *r* och ***r***. Därefter bestämdes genom planimetrering de resp. skadornas areal ävensom stamskivornas totalareal. Sedan dessa ytor för resp. upplägg-ningsformer hopsummerats dels med hänsyn till rotskivorna, dels till mittskivorna, sattes de resp. skadornas arealer i % av skivornas totalyta. Dessa procenter angivande de skilda skadornas omfattning återfinnas i tabellerna 39—44 särskilda för tall och gran, samt för snittens läge på mitten av klampen och vid storändan.

Ett studium av dessa tablåer ger vid handen:

1) Att tall genomgående vid alla upplägg-ningssätten skadats hårdare än gran av såväl blåyta som röta. Skillnaden mellan tall och gran i detta avseende är dock störst beträffande blånad.

2) Att rötskadorna beträffande helbarkat virke äro ungefär desamma i rotsnitt och mittsnitt, å randbarkat virke något större i rotsnitten än i mittsnitten samt för obarkat virke högst avsevärt större i rotsnitten. Att rötskadorna sålunda blivit mindre i mittsnitten än i rotsnitten, och denna skillnad stegrats i den mån barkningen minskat, torde bero på att veden i de ej avbarkade klamparnas mitt längre tid håller sig levande och motstår rötan, som därigenom får kortare tid att utvecklas.

3) Att blåyteskadorna i mitt- och rotsnitt i stort sett förhålla sig lika rötskadorna. I helbarkat virke äro de sålunda i huvudsak lika i rot- och mittsnitt för samma klampar, för randbarkat virke märkes särskilt för gran någon stegring i rotsnitten, medan däremot beträffande obarkat virke skadorna fått avsevärt högre omfattning i rotsnitten mot i mittsnitten. Anledningen härtill är uppenbart det hinder, som den något högre fuktigheten i mittsnitten erbjuder blåytan.

4) Att blånaden såväl med hänsyn till sin kvantitativa omfattning som intensitet hos tall i stort sett står i direkt proportion till uttorkningsgraden. Det tidigast avverkade, mest avbarkade och luftigast upplagrade virket har sålunda blånat mest.

För gran kunna visserligen förhållandena i stort sett anses gå i samma riktning, men man frapperas här av vissa mera framträdande olikformigheter i blånadens uppträdande. Sålunda ser man särskilt vid de mera fuktiga lagringsformerna (se tab. 43 och 44), hurusom en påtaglig stegring i blånaden inträtt för det under juli och 1 augusti avverkade virket. Viktminskningen för detta virke är obetydlig eller beträffande det direkt på marken lagrade negativ. Ser man åter till fuktighetshalten i t. ex. rotsnitten finner man emellertid, att denna för det ifrågavarande virket det oaktat är relativt låg t. ex. för gran som avverkats $^1/_7$, $^{15}/_7$ och $^1/_8$ resp. 73,9 %, 99,9 % och 71,8 % (tab. 38) och skadorna av blånad i dessa snitt står i direkt proportion till torrhetsgraden med resp. 23 %, 17 % och 29 % av resp. snitts yta (tab. 44).

Vår ovan uttalade förmodan, att anledningen till att sommaravverkat virke i vissa fall i högre grad än vinteravverkat skulle utsättas för blånad, vore den, att det under sommarperioden avverkade virket hade lägre ursprungsvattenhalt, synes härav bekräftad.

I detta sammanhang bör kanske även påpekas att själva ytan å det sommaravverkade virket ofta får en mörkare färg vid blåyteangrepp än ytan av det på vintern eller tidigt på våren avverkade, även i det fall blånaden längre in i veden visar mindre skillnad.

Anledningen till detta förhållande kan tänkas vara den, att den tidigt avverkade vedens yta, innan en mera omfattande infektion med blåytesvampar på sommaren kommer till stånd, i flera repriser blir rätt hårt uttorkad och ånyo fuktad, ett förhållande som i överensstämmelse med laboratorieförsöken synes medföra försämrade utvecklingsmöjligheter för blåytesvamparna.

5) Att allt virke, som avverkats 1 september och senare, i huvudsak är fritt från blånad.

6) Att lagringsrötan, i rak motsats till vad fallet var med blåytan, är starkast utvecklad i de fuktigare lagringsformerna och minst i de torra. För gran är lagringsrötan så gott som helt borta vid helbarkning och upplägg-ning i triangel.

7) Att, trots den bättre uttorkningen i det randbarkade virket, lagringsrötan där dock i det närmaste är lika betydande som i det obarkade.

Detta förhållande torde sammanhänga med att den oskadade och ännu levande barken utgör ett hinder för svamparnas inträngande.

Dessutom bör anmärkas att å en randbarkad klamp blåyteskadorna i huvudsak finnas koncentrerade till de vedpartier, över vilka barken avtagits, medan däremot lagringsrötan huvudsakligen finnes i veden under den kvarsittande barken. Då den kvarsittande barken i detta fall är död måste de skilda skadornas fördelning i virket helt stå i samband med den växlande fuktighetshalten i veden under och mellan barkränderna.

8) Att även lagringsröta saknas i alla avläggningsformer av virke, som avverkats 1 september eller senare.

Då virke avverkat 1 september eller senare ej första året i någon form skadats av lagringsröta, men helbarkat och luftigare upplagt randbarkat virke dock i viss grad uttorkats redan första året, borde det vara av intresse att se, huru dylikt virke under en kommande sommarlagring förhöll sig med hänsyn till skadors uppkomst. För detta ändamål upprepades 1924 de av oss utförda försöken med rand- och helbarkad massaved av jägmästare Enander. För att därvid ytterligare få utslag för den avverkningstid, vid

vilken lagringsskadorna för året upphöra påbörjades dessa avverkningar och avläggningar redan den $^{15}/_{6}$ 1924 och förnyades sedan den 1 och 15 i varje månad till och med den $^{15}/_{11}$.

Försöken omfattade endast hel- och randbarkat virke upplagt i triangel och utfördes i samma bestånd och enligt enahanda principer, som av oss följts 1923.

Viktundersökningar å det avverkade virket utfördes fötutom vid avverkningstillfället den 1 och 15 i varje månad till och med den 15 oktober 1924 samt därpå den 15 i varje månad från och med april 1925 till och med september samma år.

De härvid framkomna viktförändringarna framgå av tab. 45, i vilken ursprungsvikten satts till 100 och de därpå följande vikterna vid skilda vägningstillfällen omförts till procent av ursprungsvikten. Några direkta fuktighetsbestämningar å detta virke utfördes däremot ej.

Rörande uttorkningen har jägmästare Enander, utöver vad som mera direkt framgår av tab. 45, genom detaljbehandling av vägningsmaterialet fastslagit följande:

Uttorkning av de klenare klamparna försiggår avsevärt fortare än av de grövre.

Vid en diametervariation mellan 7 och 13 cm visade sig skillnaden i uttorkning under en sommarmånad för olika grova klampar belöpa sig till: för helbarkat virke 2,7 % och för randbarkat virke 1,7 % för varje förändring i diametern med 1 cm. Vid revisionen av vikterna den $^{25}/_{10}$ 1922, sedan uttorkning för året upphört, var skillnaden i vikt hos den helbarkade veden 2,1 % av ursprungsvikten för varje variation av diametern med 1 cm, medan motsvarande tal för den randbarkade veden stannade vid 1,6 %.

Vid slutrevisionen den $^{15}/_{9}$ 1925, sedan veden alltså ytterligare torkat över en sommar, var vikten i procent av ursprungsvikten vid en medeldiameter av 10 cm i topp för helbarkad tall 58,5 %, för helbarkad gran 60 %, för randbarkad tall 62,5 % samt för randbarkad gran 60,5 %.

Uttorkningsgraden visade sig därvid hos helbarkad ved oberoende av diametern — alltså driven så långt det kunnat ske — medan den däremot för randbarkad ved avtog något för de grövre dimensionerna, och detta särskilt beträffande tall, där minskningen blev 1,5 % för varje ökning av diameter med 1 cm.

I förhållande till ursprungsvikten lättade den helbarkade tallen vid i övrigt lika uttorkningsförhållanden något mera än granen. I medeltal för 1924 års avlägg förhöll sig tallens relativa viktminskning till granens som 1,05 : 1.

Beträffande randbarkad ved visade däremot gran större viktminskning än tall, vilken senare därtill under vinterlagringen upptog mera vatten än gran. Efter andra sommarlagringens slut hade i medeltal randbarkad gran lättat 1,05 gånger mera än likabehandlad tall, hos vilken senare jämväl viktminskningsvariationerna mellan klampar av olika grovlek voro större.

Uppskattningen av lagringsskadorna i de skilda avläggen skedde dels den $^{24}/_{10}$ 1924, då endast 2 gran- och 2 tallklampar ur varje avlägg uttogos och sektionerades för skadornas bestämning, samt dels vid slutrevisionen den 14—16 september 1925, då samtliga återstående klampar från avläggen undersöktes.

Denna undersökning skedde härvid å tre stycken stamtvärsnitt i tab. 46—49 angivna med I, II och III. Snitten I och III togos 30 cm från

klampens respektive ändar, II på mitten. Skadorna särskildes i tre styrkegrader, i tabellerna betecknade med resp. 1 för svagaste och 3 for svåraste form. Blåyta är markerad med b och lagringsröta med r. I flertalet snitt visade sig dock både blåyta och röta, som därtill oftast efter andra sommarlagringen voro svåra särskilja, varför de samtagits under beteckningen br. Detta har genomgående ägt rum i de kolumner, som ange skadornas av olika styrkegrad procentuella omfattning av undersökta splintytan. Det bör särskilt anmärkas, att skadornas omfattning angivits i % av splinten i motsats till vad som skett i tabellerna tidigare, där skadorna angivits i % av hela snittytan.

För att få jämförelsetal mellan skadornas omfattning vid första och sista revisionstillfället ha skadornas procentuella omfattning av splintsnittytan multiplicerats med 3 då de varit av högsta styrkegraden, 2 då då de varit av andra och 1 av första. Dessa produkter ha sedan hopadderats och summorna utgöra de i tabellerna anförda jämförelsetalen för skadorna.

Ser man nu närmare till resultatet av denna lagringsserie, sådant det framgår av revisionsprotokollet och därefter upplagda tab. 46—49, finner man först erfarenheterna från våra massavedslagringar 1923 bekräftade.

Sålunda ha även under 1924 under årets första lagring alla skador uteblivit å ved som avverkats 1 september eller senare [1]

Tallens skador under 1924 utgöras på det helbarkade virket i huvudsak av blånad, som står i direkt proportion till uttorkningen och alltså är störst hos det tidigast avverkade. På den randbarkade tallveden äro blånadsskadorna mindre, men här tillkommer i stället en del röta.

Den helbarkade granen är under första året så gott som felfri, medan den randbarkade något angripes av röta och dessutom, beträffande den under juli avverkade veden, även av någon blånad.

Vid överlagringen över ännu en sommar visar sig tallen få högst avsevärda skador i så gott som alla avläggningsformer och tider för avverkningen.

Ehuru detta ej direkt framgår av tabellerna, visade det sig härvid, att under andra året angreps den helbarkade veden i huvudsak av blånad, medan i den randbarkade rötorna dominerade. På grund av sättet för jämförelsetalens uträknande ha blånad och röta i tabellerna kommit att väga lika, men då för randbarkad ved (tab. 48 och 49) rötan dominerar, medan för det helbarkade (tab. 46 och 47) blånaden utgör huvudsakligaste skadan, är det randbarkade virkets värde i förhållande till helbarkat avsevärt mera nedsatt än som av jämförelsetalen framgår.

Den överlagrade randbarkade tallen är i huvudsak helt oduglig såväl till massaved som props, medan det helbarkade, om än på grund av blånad nedsatt i värde, dock måste anses användbart som sulfatved och props.

Den överlagrade granen visade sig vid randbarkning få avsevärda skador av huvudsakligen röta men även något blånad. Dessa skador synas kulminera för det virke, som avverkats under juli—augusti.

De uppkomna rötskadorna få en ej obetydligt sänkande inverkan på vedens värde som sulfitved, för vilket ändamål den i stor omfattning blivit oduglig, i varje fall som prima sådan.

[1] Samma försöksserier som 1924 anlades ånyo under 1925 av jägmästare ENANDER, vilkas resultat dock av utrymmesskäl här ej kunnat medtagas. I allt går resultatet dock i samma riktning, dock upphöra skadorna detta år redan vid avverkning $^{15}/_{8}$.

Den helbarkade granen har däremot vid överlagringen fått mycket obetydliga skador huvudsakligast av lindrigare blånad i sprickor, och dessa skador synas störst å det tidigast under 1924 avverkade granvirket. Anmärkningsvärt är att den helbarkade gran, som avverkats 1 sept. eller senare 1924, vid 1925 års revision i huvudsak ännu är så gott som fri från lagringsskador. De å den helbarkade granen uppkomna skadorna vid överlagringen kunna emellertid på grund av sin lindriga art i intet fall anses ha någon egentligt värdesänkande inverkan på vedens användning även som sulfitved.

Sammanfattning av de praktiska resultaten av massavedslagringen.

För vedens praktiska användning inom pappersmassefabrikationen spela de svagaste formerna av såväl blånad som lagringsröta en mycket obetydlig eller ingen roll.

Den medelstarka och starkaste formen av blånad omöjliggör däremot vedens användning till prima vit slipmassa eller sulfitcellulosa, men spelar däremot en mera underordnad roll inom sulfatindustrien, i varje fall då fråga gäller starkmassefabrikation.

De båda starkare formerna av lagringsröta få däremot för sulfitcellulosafabrikation och vitslipmassa en betänkligt kvalitetsänkande inverkan genom missfärgning, varför på så sätt skadad ved blir oduglig såväl till prima sulfitcellulosa som vitslipmassa. Därjämte har lagringsrötan i sina mera framskridna former för all pappersmassefabrikation en sänkande inverkan på vedens värde därigenom att en del av vedens fastmassesubstans sönderdelats — dess torrvolymvikt är sänkt — så att vedåtgången pr viktsenhet massa stegras. På samma sätt få lagringsrötorna en avsevärd sänkande inverkan på vedens hållfasthetsegenskaper, vilket däremot i mera ringa grad torde vara fallet med blåyteskadorna.

På grund av dessa förhållanden måste man anse lagringsrötan som en avsevärt svårare lagringsskada än blåytan, och då man av två onda ting väljer det minst onda, är givet, att man hellre tar blånad än lagringsröta, där ej båda formerna kunna undvikas.

De erfarenheter, som våra nu relaterade lagringsförsök givit, kunna sammanfattas i följande allmänna råd rörande lämpligaste behandlingsform av sådant virke (närmast massaved), som man genom lagring vill torka före dess uttransport ur skogen eller dess upparbetning.

1) Behandling.

Virket bör alltid barkas, då obarkat virke torkar mycket långsamt och dessförinnan starkt skadas av lagringsröta.

Randbarkning bör endast i undantagsfall användas, trots att den är avsevärt billigare än helbarkning, då ved, som längre tid lagras med vidsittande barkränder, synnerligen hårt angripes av lagringsröta och därjämte i ej ringa mån av blåyta.

Förhållanden, som kunna tala för randbarkning äro: om veden före den egentliga, eller torkningslagringen, flottas längre väg, då de vidsittande barkränderna lossna och falla bort av sig själva före lagringen, eller om virket utgöres av mycket klena dimensioner, som utsättas för gynnsamma torkningsförhållanden.

För övrigt bör alltid helbarkning användas, som såväl ger snabbaste och effektivaste genomtorkning, som minst betydande skadegörelse. Visserligen

kunna som ovan framhållits blånadsskadorna vid helbarkning bli mera betydande än vid andra behandlingsformer, men till gengäld blir man kvitt lagringsrötan.

2) Uppläggning.

Ju luftigare veden kan lagras och ju mera upphöjt över marken, desto bättre. Triangelklipp vid lagring i skogen och glest strölagda vältor på ordentliga underlag i luftiga lägen, då särskilda vältplatser användas, ge minsta skadorna vid uttorkningen.

3) Avverkningstid.

Gran. Vid lagring i skogen erhålles bästa torkningsresultatet med minsta lagringsskador, om granen avverkas efter 1 september på hösten eller under vintern och sedan överlagras under påföljande sommar, för att vintern därpå utdrivas. Om gran helbarkas och upplägges i luftiga klipp, tycks den i övrigt kunna avverkas när som helst utan mera betydande skador — dock med undantag för högsommaren, då blånad även i gran lätt uppkommer.

Tall. Att i skogen åstadkomma mera fullständig uttorkning av tall utan lagringsskador är omöjligt, då blånad alltid infinner sig paralellt med virkets uttorkning. Önskas mera fullständig uttorkning, bli dock skadorna minst och inskränka sig i huvudsak till blånad, om virket avverkas under vintern eller våren, helbarkas och upplägges i luftiga trianglar. Sker avverkningen på hösten och virket får torka över nästa sommarsäsong, bli skadorna däremot mera betydande. Vill man ha tallvirket mera fritt från lagringsskador, måste detta ske med eftergift i kravet på uttorkning. Om man sålunda avverkar tallen på hösten efter 1 september [1], helbarkar densamma och upplägger den i luftiga trianglar, får man före vintern en ej obetydlig uttorkning, utan skador, vilken uttorkning ofta kan vara tillfyllest för t. ex. virkets flytbarhet i flottled.

Skall virket flottas, kan därjämte, genom virkets luftiga uppläggning vid flottleden, en ej oväsentlig torkning utan nämnvärd skada äga rum före flottläggningen. Och äro flottningsförhållandena sådana, att virket mera oberoende av vårfloden kan flottläggas längre fram på våren, eller början av sommaren — dock alltid före midsommar — kan virket erhålla en relativt god uttorkning även vid direkt vinteravverkning, utan nämnvärda lagringsskador, som först börja uppträda fram på högsommaren.

[1] Denna tidpunkt, som vid våra försök i Bergslagen eller vid Garpenberg visat sig vara den, då blåyte- och lagringsrötsvamparna för året upphöra, gäller självfallet endast trakter med liknande klimat.